DOCUMENT RESUME

ED 027 227 SE 006 35

New Approaches to Science Education Research, Abstracts of Presented Papers at the National Association for Research in Science Teaching, 42nd Annual Meeting, Pasadena, California, February 1969.

ERIC Information Analysis Center for Science Education, Columbus, Ohio.

Pub Date Feb 69

Note-91p.

EDRS Price MF-$0.50 HC-$4.65

Descriptors-Biological Sciences, College Science, *Conference Reports, Conferences, Earth Scienc *Educational Research, Elementary School Science, Instruction, Physical Sciences, Research Methodolog *Research Reviews (Publications), *Science Education, Secondary School Science, Teacher Education

Identifiers-National Association for Research in Science Teach

Provided are abstracts of 44 papers presented at the annual conference of th National Association for Research in Science Teaching at Pasadena, California February 6-9, 1969. Abstracts were provided by the authors and were edited by th ERIC Center for Science Education. Major topic headings include instruction i elementary science, the teaching of biology, teacher education programs in scienc the teaching of chemistry, new instruments for research, the structure of knowledg surveys of research, the teaching of physical sciences, new approaches an materials, the development of teaching competencies, the ways children learn, and th teaching of earth science. (GR)

ED027227

SE006 351

NATIONAL ASSOCIATION
FOR RESEARCH IN SCIENCE TEACHING

42nd ANNUAL MEETING

NEW APPROACHES TO SCIENCE EDUCATION RESEARCH

ABSTRACTS OF PRESENTED PAPERS

THE HUNTINGTON-SHERATON HOTEL
PASADENA, CALIFORNIA

FEBRUARY 6-9, 1969

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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PREFACE

The ERIC Information Analysis Center for Science Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Pasadena, California, February 6 through February 9.

All persons who had papers accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC Staff to provide a general format for the abstracts. Special recognition should be given to Dr. Willard Jacobson who organized the program and obtained many of the abstracts and to Mr. Philip Dauterman of the ERIC Staff who was responsible for much of the general editorial work.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Research in Education and other publications of the ERIC system. Papers may also be requested from the authors while their limited supplies are available.

February, 1969

Robert W. Howe
Director
ERIC Information Analysis Center
for Science Education

Sponsored by the Educational Resources Information Center of the United States Office of Education and The Ohio State University.

This publication was prepared pursuant to a contract with the Office of Education, United States Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official Office of Education position or policy.

Concurrent Sessions B

Session B-1 Instruction in Elementary Science

Chairwoman: Jean Kriebs, Temple University

1. "A Procedure for Observing Teacher and Pupil Behavior in the Science Classroom," Arthur W. Friedel - Fort Wayne Regional Campus, Purdue University.
2. "A Study of the Questioning Behavior of Teachers in the Science Curriculum Improvement Study Teaching the Unit on Material Objects," Allan Kondo - Indiana University.
3. "A Study of the Use of Inquiry and Related Conceptual Understandings at Selected Grade Levels," Stanley V. Delidow - Wayne State University.
4. "Achievement Trends in Concept Learning," Stanley L. Helgeson - The Ohio State University.

A PROCEDURE FOR OBSERVING TEACHER AND PUPIL BEHAVIOR IN THE SCIENCE CLASSROOM

Arthur William Friedel
The Ohio State University

This study was designed to develop an observational procedure for describing teacher and pupil behavior in the science classroom. Bellack and others have called for the development of a variety of techniques for the collection of classroom data before future research can be done to ascertain what kinds of classroom events are related to what kinds of learning outcomes. The importance of this study is the development of observational procedure to describe the verbal and nonverbal classroom behavior of teachers and pupils. This research has also served as a prototype for other recent research conducted at the Ohio State University.

This study was carried out in two phases: (1) a record of teacher and pupil behavior was secured; and (2) the record was quantified.

The record was secured through direct observation of four Columbus, Ohio, area science classes and twelve video recordings of nine Pittsburgh, Pennsylvania, area science classes. Narrative records were made during the visitations and the viewing of tapes. Developed was a theoretical framework consisting of a model of communications as synthesized by Galloway and a theory of interpersonal needs as postulated by Schutz. Through the interplay of the narrative records and the theoretical framework, categories were developed to codify the sender, message, channel, and receiver of message behavior and the performer, behavior, and channel of non-message behavior. In describing teacher or pupil behavior, symbols were recorded every five seconds to indicate (1) sender or performer, (2) message or non-message behavior, (3) channel, and (4) receiver. To codify message behavior, twenty-nine categories were developed; to codify non-message behavior, five. Specific directions for the use of the category system with a video tape recording were developed.

The second phase of the study, the quantification of the record, was accomplished through a reliability study. Another sample of twelve video tapes of twelve science classes was recorded in Fort Wayne, Indiana. An undergraduate in science education was trained to use the observational procedure. After about 30 hours of viewing, discussing, and recording symbols corresponding to the science classroom behavior of the teacher, the observers selected a random sample of 15 five-minute segments of recorded tape for coding. Scott's coefficient was calculated for each five-minute segment of tape coded and for the total 75 minutes of tape coded. The range of the coefficients for the 15 five-minute segments was found to be from 0.57 to 0.90, and the median was 0.80; for the total viewing time, the coefficient was 0.92. This procedure established the observational device as a useable instrument.

The researcher then codified the behavior of the pupils as recorded on the same 15 segments of video tape selected for teacher observation. Obtained were percentages of behavior recorded in each category of sender or performer, message or non-message or behavior, channel and receiver.

Six major conclusions of science classroom behavior were obtained:

1. The predominant features of science classroom behavior were the message behaviors of the teacher and the non-message behaviors of the pupils. Message behavior accounted for 64 per cent of teacher behavior and non-message behavior accounted for 83 per cent of pupil behavior.

2. Teacher impersonal message behavior accounted for more messages than personal behavior--56 per cent was recorded as impersonal, 44 per cent personal.

3. There was relatively infrequent use of reinforcement by the teachers--2 per cent of the recorded behavior--1 per cent positive and 1 per cent negative.

4. There was an infrequent categorization of behaviors associated with experimental information--5 per cent as compared with 31 per cent designated as authoritative information and 14 per cent drill.

5. There was frequent use of the verbal channel for messages by the teacher--87 per cent of the teachers' messages was sent via this channel alone.

6. Non-message behavior required the nonverbal channel exclusively. The nonverbal channel was used for 100 per cent of the teachers' and pupils' non-message behavior.

A STUDY OF THE QUESTIONING BEHAVIOR OF TEACHERS IN THE SCIENCE CURRICULUM IMPROVEMENT STUDY TEACHING THE UNIT ON MATERIAL OBJECTS

Allan Kiichi Kondo
Indiana University

The purpose of this project was to study the questioning behavior of teachers in the Science Curriculum Improvement Study (SCIS), and the possible relationship between their questioning behavior and the different types of SCIS lessons. The SCIS has identified at least two main types of lessons: Invention lessons in which teachers introduce a concept to children, and Discovery lessons in which children apply the concept to new situations.

The same sequence of four lessons, two Invention and two Discovery, in the SCIS unit on Material Objects, was tape-recorded for four first-grade teachers in the same school. The transcripts of the tapes were analysed in terms of the complexity of their questioning behavior using question-response-comment units called incidents, the question types (Routine, Cognitive-Memory, Convergent, Evaluative, and Divergent), teacher reactions to responses or to her own questions, and the transition probabilities of one question type followed by the same or other types.

The analyses of the questioning behavior of the four teachers in the SCIS revealed the following results:

1. Overall, there was a fairly consistent pattern of questioning by the four teachers across the four lessons. The most complex lesson was Lesson 20 (Invention of the Comparison of Objects Using Signs).

2. Differences in the complexity of questioning patterns were more striking when individual teachers were compared. Certain teachers had a more complex pattern than others.

3. On the average, the percentages of Routine and Cognitive-Memory questions across lessons seemed to be influenced by the lesson being taught, but not by whether the lesson was an Invention or a Discovery lesson *per se*. The way the lesson was approached--i.e., teacher demonstration, children handling materials, etc., seemed to have a greater influence. When the lesson was largely handled through a demonstration, the percentages of Routine questions were relatively low and the percentages of Cognitive-Memory questions were relatively high.

4. There was a fairly uniform percentage of Convergent questions across all lessons, about one-half of all questions asked being Convergent.

5. The relative frequencies of Evaluative questions were low in all lessons.

6. While there were low percentages of Divergent questions overall across the lessons, the Invention lessons (Lessons 20 and 21a) produced the highest percentages.

7. In general, it is suggested from the data that the way the lesson is approached has a greater influence on the types of questions asked than the type of lesson per se.

8. In most cases, the differences of question types among individual teachers were more striking than the averages across lessons. This points out the importance of the individual teacher's style in the types of questions she asks.

9 In terms of the teacher reactions to children's responses and to her own questions, the most pronounced differences across lessons were found in Lessons 20 (Invention) and 22 (Discovery), on the one hand, and Lessons 21a (Invention) and 21b (Discovery), on the other. The percentages in categories of Repetition of responses and Question following question were higher in the first pair mentioned than in the second. Again, vast differences were found between individual teachers. This revealed the characteristic ways in which different teachersreact to children's responses and to their own questions.

10. One type of question tends to be followed by questions of the same type to a greater extent than would be indicated by the overall distribution.

The information gained in this study might be used in the consideration of teaching strategies, curriculum modifications, and teacher education.

A STUDY OF THE USE OF INQUIRY AND RELATED CONCEPTUAL UNDERSTANDINGS AT SELECTED GRADE LEVELS

Stanley V. Delidow
Wayne State University

There are numerous current programs in science education that attempt to use the inquiry approach of 'process'. Yet there is comparatively little information on how children utilize or react to open or fluid inquiry. What is known has been generally developed within such specific programs as E.S.S., A.A.A.S., S.C.I.S., E.S.C.P., and B.S.C.S.

There is some need to research the question: How do children, K-12, react to inquiry when given similar problems and placed in similar situations? Implications from this type of research could attempt to re-evaluate the presence of any pattern of development of inquiry skills, could attempt to correlate conceptual understanding with process skills, and could have bearing upon the validity of topic centered spiral curriculum.

The problem being explored in this study is the following: How do children in the kindergarten, second, fifth, eighth and eleventh grades react to inquiry when presented similar problems in similar situations?

The research is to be conducted during the fall of 1968 in the West Bloomfield Hills School District, northwest of the city of Detroit. This school district will allow the study to select as homogenous a student population as possible.

The grades selected for the study are kindergarten, second, fifth, eighth and eleventh. The reason for such a selection is two-fold. First, not every grade level could be examined in the allotted time for this research, nor would it be deemed essential to do so. Second, in pilot situations involving the elementary schools, it was ascertained that discrete differences could be found between these grades. The eighth and eleventh grades were chosen as being representative of two levels of secondary school students. Two classes from each of the chosen grades are to be selected so as to produce a total population of between 250 and 300 students.

Students will be asked to participate in one of two problems. The procedure is to interview each student separately for between twenty and thirty minutes, placing his reactions to the problems presented on video tape.

The first problem involves the ability to see pattern in selected samples in an attempt to accurately estimate the colors in a population of colored wires. In this activity, observation and understanding, probability, measuring, selection of sample and grasp of numbers are most important.

The second problem involves a cardboard tube, blocks, and three marbles. Two of the marbles are exactly the same size (4mm) one glass (93 mg), the other copper (358 mg). The third is a 6mm glass bead that weighs 300 mg. Students will be asked which of the two small marbles will roll farther and then asked to prove their answer, using some procedure. The object is to have the students devise a situation that will demonstrate their beliefs, ideas, or ways of finding out.

Each interview has a standardized but flexible format and produces a situation in which the interviewer initially sets the question. This calls for a loosely structured but informal situation in which, after the problem is suggested, the student is left alone to his own devices.

The evaluation of each interview will be done by means of a loose scale that parallels the interview schedule. Such a schedule would attempt to rate each child in two areas: one, level of recognition, understanding of concept dealt with; two, exhibited use of process skills.

As a final check on research procedures, a different educator will ascertain the level of prejudice produced by the interviewer.

It is believed that this research, using this format, will produce evidence to show that there does exist a pattern of developmental ability in open inquiry and that it does to some degree correlate with the Piagetian model of the child's understanding of reality. This research will also give evidence to show that, while levels of sophistication vary, all types and aspects of inquiry skills do appear at each level.

ACHIEVEMENT TRENDS IN CONCEPT LEARNING

Stanley L. Helgeson
The Ohio State University

Differences in learning achievement attained by pupils of differing maturity are important considerations in teaching elementary school science. If understanding is hierarchical in nature, we must then be concerned with pupil attainment at various complexity levels within this hierarchy. Two questions arise: Do pupils of differing maturity attain the same level of achievement; and do such pupils achieve in the same ways at each of the levels of understanding?

Using grade enrollment as an indicator of maturity, the investigator considered the foregoing questions in the form of the following problems:

1. Are there significant differences among the levels of the mean scores achieved by pupils in grades 2-6 for each of the knowledge, comprehension, and application levels?

2. Are the trends of the mean scores achieved by the pupils in grades 2-6 parallel for each of the knowledge, comprehension, and application levels?

A sample consisting of 12 pupils was randomly selected from each of grades 2-6 from an elementary school in central Wisconsin. An instructional unit was developed for each of eight concepts selected from within the conceptual scheme of force; the order of events within each unit was fixed to provide for comparable instruction of all pupils.

Evaluation was by paper-and-pencil multiple-response items designed to test for achievement at each of the knowledge, comprehension, and application levels. The instruments contained five items per concept for a total of 40 items at each of the knowledge, comprehension, and application levels.

Analyses of the evaluation data reveal the following results:
Knowledge--There are significant differences among the levels of the mean scores achieved by the pupils in grade 2-6. The trends of the mean scores are parallel for pupils in all grades when compared across concepts.
Comprehension--There are significant differences among the levels of the mean scores achieved by the pupils in grades 2-6. The trends of the mean scores cannot be established as being parallel when compared across concepts.
Application--There are significant differences among the levels of the mean scores achieved by the pupils in grades 2-6. The trends of the mean scores were not parallel when compared across concepts.

It would appear that, based on these results for this sample, not only do differences in level of achievement occur for pupils of differing maturity, but that differences also occur in the ways in which they achieve.

This research was performed pursuant to contracts with the United States Office of Education, Department of Health, Education, and Welfare, under provisions of the Cooperative Research Program at the University of Wisconsin Research and Development Center, Center No.C-03, Contract OE 5-10-154.

Principal Investigators for the Science Concept Learning Project were Dr. Milton O. Pella and Dr. George T. O'Hearn.

Session B-2 The Teaching of Biology

Chairman: Burton Voss, University of Michigan

1. "An Exploratory Investigation of Verbal and Non-Verbal Behaviors of BSCS Teachers and Non-BSCS Teachers," LeVon Balzer - Western Washington State College.
2. "An Exploratory Study of the Verbal and Non-Verbal Behaviors of Biology Teachers and Their Relationship to Selected Personality Traits," Thomas Parker Evans - Oregon State University.
3. "A Comparison of the Ideological Orientations and Personality Characteristics of Innovative and Non-innovative High School Biology Teachers," Wayne K. Hoy - Rutgers - The State University of New Jersey and Jacob W. Blankenship - Oklahoma State University.

AN EXPLORATORY INVESTIGATION OF VERBAL AND NON-VERBAL BEHAVIORS OF BSCS TEACHERS AND NON-BSCS TEACHERS

LeVon Balzer
Western Washington State College

The purpose of this study was to achieve the following objectives:

1. To develop an instrument for the categorization of biology teacher verbal and non-verbal behaviors.

2. To record and encode behaviors and patterns of biology teacher behavior by means of utilization of the instrument on video tape recordings taken in the classroom.

3. To identify aspects of teacher behavior patterns that differ significantly among teachers and aspects that appear relatively similar or correlate highly among teachers.

4. To identify behaviors and/or patterns of teacher verbal and non-verbal behavior that differ significantly between BSCS teachers and non-BSCS teachers.

This investigation was one of two studies which were parallel in part and were designed to contribute to the development and use of a category system by means of video tape recordings. The instrument (Biology Teacher Behavior Inventory) was developed inductively from the complete written records of behaviors obtained from the video tapes. All identifiable verbal and non-verbal behaviors influencing the teaching-learning situation were included. The empirical data from the video tapes constituted the basis of the category system.

Encoding was accomplished by writing symbols representing the appropriate categories, subcategories, and subdivisions in the columns of the Data Record representing verbal, congruent, non-verbal, and contradictory behaviors. As long as a given behavior continued, pencil dots were continued under those symbols at approximately one-second intervals. Condensation of data involved identification of predominant behaviors based on time consumed within ten-second intervals.

Observer agreement figures on the three groups of behavior samples were 0.92, 0.95, and 0.93 as obtained by use of the Scott Index of Intercoder Agreement.

The completed Biology Teacher Behavior Inventory was utilized on video tapes of five class sessions of four BSCS teachers and four non-BSCS teachers. In this study, these data were then examined by inspection and non-parametric statistical tests for similarities and differences among the teachers and for differences between the BSCS teachers and non-BSCS teachers.

The following conclusions and inferences were drawn from the processes and data:

1. An instrument can be developed on a category basis which incorporates the verbal and non-verbal behaviors of biology teachers.

2. Some aspects of the behaviors were identified which correlated highly for these teachers. Most evident were the similarities in pattern of ranks of the various categories, subcategories, and subdivisions based on percentages of predominant behaviors.

3. Some aspects of the behaviors differed significantly among the teachers. These differences were observed within specific items, such as categories or subcategories. Teachers differed significantly (at the .05 level) with respect to "Laboratory Management," "Control," "Release," "Scientific Process," Facilities Communication," and "Negative Affectivity."

4. No significant differences were found between the BSCS teachers and the non-BSCS teachers. "Scientific Process" approached significance at the .05 level, and it was evident by inspection that the BSCS teachers were higher in "Scientific Process" behaviors than the non-BSCS teachers.

5. The inductive method of instrument development based on empirical data in the form of complete records of teacher verbal and non-verbal behaviors has considerable potential in behavioral research.

6. Opportunities for improvement of behavioral research are greatly enhanced by the use of video tape recording equipment. For example, a second-by-second account of teacher behavior can thus be developed.

7. Sensitivity to forms of expression, both verbal and non-verbal, and communication acts can be incorporated into an instrument without necessitating that the structure of the instrument be restricted to either framework.

8. Non-verbal behaviors may constitute a much greater proportion of the total behaviors of the teacher than has been hitherto reported. Non-verbal components influencing the teaching-learning situation were found to occur in 65.22 percent of all behaviors of the teachers studied.

AN EXPLORATORY STUDY OF THE VERBAL AND NON-VERBAL BEHAVIORS OF BIOLOGY TEACHERS AND THEIR RELATIONSHIP TO SELECTED PERSONALITY TRAITS

Thomas Parker Evans
Oregon State University

This investigation was designed to test the following two hypotheses:

1. A reliable category system for first-hand systematic observation of the verbal and non-verbal behavior of high school biology teachers, in both classroom and laboratory instructional situations, can be developed.

2. There is a significant positive correlation between selected personality traits and the verbal and non-verbal behaviors exhibited by high school biology teachers in both classroom and laboratory instructional situations.

In order to test the first hypothesis, thirteen video tape recordings, each one class period in length, were made of eleven high school biology teachers during their regular laboratory and classroom presentations. These recordings were used to develop the _Biology Teacher Behavior Inventory_ and a method of encoding behavioral data.

The category system, which was composed of seven major categories, was developed in an inductive manner, i.e., it progressed from a narrative list of teacher classroom behaviors to the individual categories and finally into the _Biology Teacher Behavior Inventory_. The list of teacher classroom behaviors was later organized into a glossary of teacher classroom behaviors.

The method of encoding consisted of viewing the video tape recordings and identifying, classifying, and recording the teacher classroom behaviors onto a data record. The behaviors were classified into the _Biology Teacher Behavior Inventory_ according to the inferred intent of the behavior and according to one of the following forms of expression: Verbal, Congruent, Non-verbal, or Contradictory. The encoded behaviors were recorded in rows, top to bottom, on the data record to preserve the sequence of behaviors.

Once the encoded data record was obtained, ten-second time intervals were determined with the aid of an audio recorder. Each time interval was examined, and the predominant behavior for each interval was determined by the behavior which consumed the largest portion of ten-second interval.

Fifteen, five-minute samples of behavior were drawn at random from the thirteen video recordings, and each sample was independently observed and encoded by two observers. Inter-observer agreement was calculated, and an overall inter-observer agreement was found to be .92. Inter-observer agreement was rechecked at the midpoint and again at the end of data collection and found to be .95 and .93, respectively.

In an effort to test the second hypothesis, forty video tape recordings, five for each teacher, were made of eight biology teachers over a period of three months. Both laboratory and classroom instructional periods were recorded, and each tape was one class period in length. The tapes were analyzed using the Biology Teacher Behavior Inventory and the method of encoding developed for testing the first hypothesis.

The personality data were obtained by administering the Guilford-Zimmerman Temperament Survey to each of the eight biology teachers.

The Spearman Rank Correlation Coefficient was used to correlate the behavioral and personality data. The .05 and .01 levels of significance were determined from a table of critical values for the Spearman Rank Correlation Coefficient.

The first hypothesis was supported by the Biology Teacher Behavior Inventory and the method of encoding developed and used in this study. That is, the instrument met the stated definition of a category system, and the reliability, defined as inter-observer agreement, was found to be in excess of .90.

It was concluded from the statistical findings that there were significant positive correlations between the selected personality traits and certain verbal and non-verbal teacher classroom behaviors. However, these findings were highly suspect, i.e., there were no more significant positive correlations than one would expect to find by chance alone.

A COMPARISON OF THE IDEOLOGICAL ORIENTATIONS AND PERSONALITY CHARACTERISTICS OF INNOVATIVE AND NON-INNOVATIVE HIGH SCHOOL BIOLOGY TEACHERS

Wayne K. Hoy
Rutgers - The State University

Jacob W. Blankenship
Oklahoma State University

In this study it was assumed that certain ideological orientations and personality characteristics would facilitate innovation and change.

Innovative and non-innovative high school biology teachers were predicted to differ significantly with respect to (1) pupil control orientation and (2) the set of personality characteristics termed "capacity for independent thought and action."

Innovative and non-innovative subjects were identified from a sample of 164 high school biology teachers attending four summer institutes financed by the National Science Foundation. The Pupil Control Ideology Form and the California Psychological Inventory were the operational measures of the dependent variables.

The hypotheses of the study were tested and confirmed by the t-tests for differences between means of noncorrelated samples of unequal size.

Concurrent Sessions C

Session C-1 Teacher Education Programs in Science

Chairman: Robert Lepper, California State College at Fullerton

1. "Elements of Successful In-Service Education for Elementary Science," Elizabeth Hone, Sherman Oaks, California.

2. "An Assessment of Science--A Process Approach in a Cooperative College-School Science Project," William S. LaShier, Jr. - Kansas State Teachers College.

3. "Report on a New Single Course Combining Content and Technique in the Science Preparation of Elementary School Teachers," Sidney Rosen - University of Illinois.

4. "Analysis of Instructional Outcomes of Students Involved with Three Courses in High School Chemistry," Verne Aubry Troxel - University of Iowa

ELEMENTS OF SUCCESSFUL IN-SERVICE EDUCATION FOR ELEMENTARY SCIENCE

Elizabeth Hone

Implementation of any new curriculum material depends upon the extent and quality of in-service education of teachers in the new material. Pre-service is too little and too late. As compared to the number of teachers in service, pre-service education involves too small a fraction of the profession. Changing curriculum via new materials would occur at snail's pace if it were attempted only through the pre-service population of teachers.

For years, major publishers have committed a considerable budget for consultant salaries and materials to implement new books and related materials directly with teachers in-service. Indeed,

> "....one private agency (a publisher) adapted the tactics and strategy of the federal and foundation-sponsored hypercommittee in calling upon the services of a widely representative group of scientists, science educators, administrators, supervisors and teachers, selecting, of course, several individuals, who were then responsible for directing the project. The result was the development of "experimental try-out schools," "experimental try-out editions," wide feedback resulting in many revisions; the result was the development of a hypertext or a multiplicity of materials; these included classroom laboratories, individualized investigations, laboratory manuals, construction manuals, as well as texts, classroom guides and tests."*

Following the template established by the Physical Science Study Committee, those involved in the majority of new science curriculum projects are providing for subsidized training of selected teachers to test and proselytize materials as developed. Implementation of any new science material relies heavily upon in-service education to overcome several obstacles.

These obstacles include:

teachers' negative attitudes toward science.
teachers' lack of skills in the use of simple equipment.

As reasons for not teaching science, studies show teachers cite:

lack of equipment
inadequate science background
lack of time and space

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* Paul F.Brandwein, "Trends and Issues in Science Education," in Innovations 1966, Syracuse University.

These three reasons can be shown to be more apparent than real when in-service science is skillfully structured around these three elements:

Program and Equipment
Personnel
Time and Place

The following report is based upon experience and observations with several hundred teachers over a two-year period. The sampling represents 150 workshop meetings held between 50 districts. As a result of these experiences, the three above-named elements emerged as determinants for successful in-service education in elementary science. Pre-planning for these elements with district consultants will be described; overall and specific plans for a workshop series and individual meetings will be cited; and evidence of individual and group growth both during and several months later will be offered. Moreover, evidence from control situations which lacked the blending of essential elements will be presented, and examples of follow-up activities will be considered.

AN ASSESSMENT OF SCIENCE - A PROCESS APPROACH IN A COOPERATIVE COLLEGE-SCHOOL SCIENCE PROJECT

William S. LaShier, Jr.
Kansas State Teachers College

A Cooperative College-School Science Project provided N.S.F. support for 47 elementary school teachers and principals for a six-week summer period and additional assistance during the following academic year of 1967-68. The project was planned jointly by the staff of Lawrence, Kansas Unified School District #497, and Dr. Clark Bricker and Dr. William S. LaShier, Jr. of the University of Kansas.

The summer institute participants used the *Physical Science for Non-Science Majors* materials. In addition, the rationale and use of the *AAAS Science - A Process Approach Materials* were studied and subsequently implemented by 26 teachers of kindergarten through grade three.

The summer institute participants had a pre-test mean of 66.7 points out of a possible 100 on Form A of the AAAS *Science Process Measure for Teachers*. After six weeks of instruction, the mean score increased to 80.1 as measured by Form B of the same test.

The evaluation of the success of the subsequent academic year program was based, in part, on a pre- and post-test design using student achievement in science as the criterion. Four sets of Competency Tasks were compiled to be used in determining any gain in student achievement over a period of a year. Each set of competency tasks was selected from pre-existing AAAS tests that accompanied each of the exercises that were to be taught at a particular grade level during the 1967-68 school year. Each of the sets of competency tasks was limited in scope so that the test could be administered to an individual student in approximately thirty minutes. The research design provided for the pretesting in September of 15 control students and 20 experimental students randomly selected at each grade level from kindergarten through three. Both the experimental and control groups were tested again in May, 1968, to determine any gain in achievement.

The four sets of Competency Tasks, corresponding to the four grade levels, were administered by a team of four individuals acquainted with the rationale of the AAAS program. To insure an objective assessment, an examiner tested both the control and experimental groups at a particular grade level.

The reliability of each of the four sets of Competency Tasks was determined by means of the Kuder-Richardson Formula 21. An item analysis of the post-test scores of the experimental group provided validity and difficulty indices for each item.

Two null hypotheses at each grade level were stated to test whether there was an initial significant difference between the two groups and also whether the experimental group exceeded the achievement of the control group after encountering the AAAS program.

At all four grade levels, there were no initial significant differences at the .05 level between the control and experimental groups as measured by the pre-test sets of competency tasks. After completing the sequence of AAAS exercises, both groups were post-tested with the same instruments. In all four grades, significant achievement differences existed in favor of the experimental group. The level of significance at the kindergarten level was .05. In the first grade, the level of significance was .025. In the second grade, a .002 grade level of significance was obtained. The level of significance for the third grade group was .05. The results of the study indicated that the students involved in this AAAS program consistently achieved more of the stated objectives than the students in the control group.

REPORT ON A NEW SINGLE COURSE COMBINING CONTENT AND TECHNIQUE IN THE SCIENCE PREPARATION OF ELEMENTARY SCHOOL TEACHERS

Sidney Rosen
University of Illinois

Established during the summer of 1967 at the University of Illinois was a new course which combined a science course with an elementary school science methods course. Thus, the first semester of the physical science course in the Liberal Arts College (DGS 141) and the one-semester methods course elective (El Ed 335) were made available to sophomore students who had not yet fulfilled their physical science requirement and who, under normal circumstances, would not have been eligible to elect El Ed 335, a junior-senior course.

Briefly, the apologiae for this innovation are as follows: (a) the impact of the new secondary-school curricula in science has been to increase the pressure on elementary-school teachers to teach more and "better" science; (b) the teaching of the newly developed elementary-school science curricula has been hindered by the inability of teachers to teach them, or at least to teach them in the sense intended by the developers; (c) the major area of lack of preparation on the part of elementary school teachers seems to be in the physical sciences, particularly astronomy and physics.

It would be ideal to graduate a teacher who is well-grounded in the physical sciences; however, in view of the typical four-year elementary education curriculum, such an ideal is rarely, if ever, attained. Nevertheless, it should be possible to graduate a prospective elementary school teacher who has gained an insight into the nature of fundamental physical concepts and who is prepared to "translate" these concepts at the child's level of sophistication. More hopefully, such a teacher ought to be able to evaluate any new elementary-school science curriculum she is asked to teach.

This report will discuss at greater length the two courses involved, the techniques of combination, and the kinds of activities experienced by the students and faculty involved. Since the combined course will have already been offered during the first semesters of two years (the present and the past academic years), something can be said about student attitudes and accomplishments. No formal statistical measurements of success or failure have as yet been attempted.

ANALYSIS OF INSTRUCTIONAL OUTCOMES OF STUDENTS INVOLVED WITH THREE COURSES IN HIGH SCHOOL CHEMISTRY

Verne Aubry Troxel
University of Iowa

Three courses of study in chemistry, Modern Chemistry, CHEMS and CBA were compared to determine if there were any difference in the degree to which these courses were meeting their common objectives. The objectives of these courses are such as to indicate they will provide for the student (1) a greater understanding of chemistry, (2) a greater understanding of science, (3) a greater ability to think critically, and (4) a better attitude toward science.

Four instruments were used on a pretest and post-test basis to determine if there were any difference in the attainment of the objectives of the three chemistry courses. These instruments were (1) ACS Cooperative Examination - General Chemistry, Form 1963 (ACS), (2) Test on Understanding Science, Form W (TOUS), (3) Watson-Glaser Critical Thinking Appraisal, Form YM (WGCTA), and (4) Prouse Subject Preference Survey (Prouse). In addition a Teacher Performance Scale (TPS) was administered on a post-test basis to determine if there were any correlation between achievement on the various measures and the student's opinion of the teacher's ability to make classroom materials understandable. Including all subtest and total test scores, each student received and answered a battery of fifteen examinations. A total of 1333 students and 23 teachers took part in the study in Iowa and Illinois. The students were compared on the basis of (1) the total group without regard to grade level or ability level, (2) each grade level without respect to ability level, (3) each grade level subdivided into three ability groups as determined by the Watson-Glaser Critical Thinking Appraisal pretest total score. The comparison was accomplished by analysis of covariance. Correlations were determined by use of the Pearson Product-Moment Correlation calculation.

In terms of the total group, the analyses show that students enrolled in CHEMS and CBA perform significantly better on the ACS, TOUS, and WGCTA examinations than do students enrolled in Modern Chemistry. Students in the CHEMS and Modern Chemistry courses tend to rate the subject of chemistry higher in terms of preference than do students enrolled in the CBA course, as measured by the Prouse.

In terms of the various grade levels the analyses show that, regardless of grade level, students who are enrolled in the CHEMS and CBA courses perform significantly better on the ACS, TOUS and WGCTA examinations than do students who are enrolled in the Modern Chemistry course. Students in grade 11 enrolled in the Modern Chemistry and CHEMS courses tend to prefer the subject of chemistry to a greater extent than do students enrolled in the CBA course, as measured by the Prouse.

In terms of the three ability levels for grade 10 the analyses show that students enrolled in CHEMS develop a significantly better understanding of chemistry as measured by the ACS regardless of their ability level than do students enrolled in _Modern Chemistry_ or CBA. Also students who are enrolled in CBA in the upper third of their class develop into significantly better critical thinkers than students enrolled in the CHEMS course as measured by the WGCTA.

In terms of the three ability levels for grade 11, students in the lower and upper thirds of their ability level who are enrolled in CHEMS and CBA develop a significantly better understanding of science than do students enrolled in the _Modern Chemistry_ course, as measured by the TOUS. Students in the lower two-thirds of their ability group who are enrolled in CHEMS and CBA tend to develop a significantly better ability for some aspects of critical thinking than do students in _Modern Chemistry_ courses, as measured by the WGCTA.

In terms of the three ability groups for grade 12, CBA students tend to develop a significantly better understanding of chemistry than do students enrolled in the _Modern Chemistry_ course, as measured by the ACS. Students enrolled in CBA and in the lower third of their ability group develop a significantly better understanding of science than do students enrolled in the _Modern Chemistry_ or CHEMS courses, as measured by the TOUS. CBA and CHEMS students in the lower and upper thirds of their ability group develop certain aspects of critical thinking significantly better than do _Modern Chemistry_ students, as measured by the WGCTA.

In general the correlations between the TPS and the other variates were extremely low indicating only a concomitant relationship.

Session C-2 On the Teaching of Chemistry

Chairman: Frank X. Sutman, Temple University

1. "The Oxidation-Reduction Concept," Madeline Prager Goodstein - Central Connecticut State College.

2. "Assessment of the Cognitive Ability Evaluation in Students of Conventional and Modern High School Chemistry," John F. Schaff - Syracuse University.

3. "An Experimental Study to Determine the Relative Effectiveness of Four Methods of Laboratory Reports in the Teaching of Chem Study Chemistry," William Torop - Upper Darby, Pennsylvania, Senior High School.

4. "Learning Difficulties Encountered by Students Studying the Chem Study Program," Ilene Joyce Swartney - State University College at Buffalo.

THE OXIDATION-REDUCTION CONCEPT

Madeline Goodstein
Central Connecticut State College

Although the oxidation-reduction concept is much used in chemistry, a search of the literature reveals that no single definition is currently accepted in all fields of chemistry. In this study, a new definition has been educed which subsumes the maximum number of common elements of the concepts now in use. An oxidation-reduction is defined as a chemical reaction during which an atom takes possession of one or more electrons from another atom because it is intrinsically a more powerful electron-attractor. Transfers of electron possession occur when an electron pair is attracted to, from, or through the position of equal sharing to a new position, or when an electron is transferred from one particle to another. A shift in degree of electron possession is not an oxidation-reduction.

Based upon the above definition, the usual meaning of oxidation, reduction, oxidizing and reducing agents, and oxidation state are redefined, and a convenient new term, bond oxidation number, is introduced. Complex formation is non-oxidative when the bonding occurs via a lone electron pair with an atom of lesser electron-attracting power.

The above definition restricts redox reactions to transfers of electron possession which take place due to atomic electron-attracting power. It eliminates those reactions which are due to inductive or polarization effects or are radiolyses or photoexcitations.

The determination of the electron-attracting power of an atom is seen to be a difficult problem. Of the several methods considered, Pauling's electronegativities seems to be the best measure available.

When the energies of redox reactions are examined, it is seen that they are directly related, although the relationship to electronegativities is not simple.

It is shown that, significantly, oxidation-reductions take place by characteristic mechanisms which often differentiate them from non-redox processes. The mechanisms may be divided into three major groupings with several separate sub-groupings for each. The sub-groups include many reactions not ordinarily studied because they do not fit conveniently into classification systems now in use.

Redox process and redox product are closely linked; inorganic and organic reactions proceed by distinctly different mechanisms. However, when electrons are transferred to or from a coordinate complex with an accompanying change in coordination number, mechanisms of each type may occur depending upon the conditions.

The redox concept, far from being arbitrary, is a classification of certain real changes in electron configuration. An accounting of these changes is feasible through the use of oxidation numbers. The standard set of rules for assigning oxidation numbers is readily justified in terms of the new definition.

The possibility exists that other areas in science may benefit from such intensive studies as this one, especially when the topic crosses ordinarily separate areas. The professional educator who is undertaking a doctoral or post-doctoral project is almost uniquely qualified for such an exploration.

ASSESSMENT OF THE COGNITIVE ABILITY EVALUATION IN STUDENTS OF CONVENTIONAL AND MODERN HIGH SCHOOL CHEMISTRY

John F. Schaff
Syracuse University

Several comparisons have been made between modern and conventional chemistry courses with attempts to elucidate the specific complex behaviors purported to be developed by the modern courses. Distinct insights into identifying the complex behaviors developed by the modern courses have been produced by tests based on the behavioral descriptions contained in the _Taxonomy of Educational Objectives, Handbook I: Cognitive Domain_. In this research, students were compared using an instrument designed to measure Evaluation, the most complex of the behaviors represented in the _Taxonomy_.

The instrument, _Assessment of Evaluation Ability in Chemistry_, was developed to measure the cognitive ability, Evaluation, in high school chemistry. It consisted of two equivalent forms, Form J and Form S, designed to measure Evaluation in the unit of content, Kinetic-Molecular Theory, which was taught in both the conventional and modern curricula. A control for Knowledge, the lowest of the six hierarchical categories of the _Taxonomy_, was incorporated to serve as a means of comparing the knowledge of students in the two treatment groups. No attempt was made to control for, or to measure, the intervening categories of the _Taxonomy_.

The Knowledge test was a part of each form of the instrument and was administered prior to the Evaluation test. It consisted of multiple-choice items designed to measure the recall of specific facts and ideas related to Kinetic-Molecular Theory.

Nine problems designed to measure a student's Evaluation ability based on his knowledge of Kinetic-Molecular Theory comprised the Evaluation test. Each problem was broken down into five specific items calling for separate judgments based on different criteria in order to measure as much of the Evaluation process as possible. Each item called for a yes or no response to a statement which was followed by a request for an explanation of the decision given.

Twenty-four classes, 12 for each treatment group, were selected from seven schools in the northeastern section of Illinois. The classes were divided equally among 12 teachers with no more than two teachers represented by one school. The instrument was mailed to the schools and administered to the classes during a six-week period in April and May, 1968. All students were tested first with Form J and then with Form S of the instrument.

When class mean scores on the Knowledge test were compared using the BMDO8V Analysis of Variance program, no differences were observed at the .05 level of significance between the treatment groups.

A comparison of the two treatment groups on the Evaluation test revealed that the mean class scores of the modern curricula were substantially higher than those for the conventional curricula. A statistical analysis of the student scores showed that subjects given instruction in modern chemistry differed from those given instruction in conventional chemistry curricula at the .01 level of significance.

This investigation disclosed differences in the cognitive ability, Evaluation, of students given instruction in modern and conventional high school chemistry curricula, while concurrently demonstrating in the same students an equivalent performance on their Knowledge ability. Students taught the modern curricula demonstrated a higher performance in Evaluation than students taught the conventional curricula. These results substantiated the hypothesis that there were differences in the complex cognitive ability, Evaluation, developed in students by the two curricula. The results suggest that there may also be differences in other complex cognitive abilities of the *Taxonomy*.

AN EXPERIMENTAL STUDY TO DETERMINE THE RELATIVE EFFECTIVENESS OF FOUR METHODS OF LABORATORY REPORTS IN THE TEACHING OF CHEM STUDY CHEMISTRY

William Torop
Upper Darby Senior High School

The problem considered in this study was the effect of different types of laboratory reports on measured outcomes of CHEM Study Chemistry.

Most of the laboratory-centered science courses for the secondary schools have some type of written laboratory report associated with them. The value of these written reports, however, has not been conclusively demonstrated. There is no recent research which addresses itself specifically to this problem.

The subjects, divided into four treatment groups, were eleventh and twelfth grade, college preparatory, high school chemistry students at the Upper Darby Senior High School, Upper Darby, Pennsylvania, during the school year 1967-1968. The first treatment group was required to submit an essay laboratory report. The second treatment group filled in the blanks on mimeographed laboratory sheets prepared by the investigator. The third treatment group answered the questions in the laboratory manual. The fourth treatment group did not prepare any written report. All four groups were taught by the investigator and used the CHEM Study textbook and laboratory manual, Chemistry An Experimental Science. All assignments, quizzes, tests, and experiments (except for report format), were the same in each treatment group. The evaluation instruments administered as pre-tests only were the Otis Quick Scoring Mental Ability Gamma Test and the American Chemical Society-National Science Teachers Association High School Chemistry Test. Used as both a pre-test and post-test were the Watson-Glaser Critical Thinking Appraisal and the Test on Understanding Science. The following tests were administered as post-tests only: Chemical Education Material Study Achievement Tests, Chapters 1-4, 5-7, 8-10, and Semester Final; Laboratory Technique and Apparatus Test for High School Chemistry; Cooperative Science Tests, Chemistry, Part II; and a test on the visual identification of laboratory equipment.

On the CHEM Study Semester Final the mean test scores of the group using the mimeographed laboratory sheets was significantly higher (at the .05 level) than those of both the essay report group and the no written report group. However, there were no significant differences on measured outcomes in the other evaluation instruments administered.

Based on the results of this investigation, it is recommended that report sheets be prepared by the teacher in order to increase achievement in high school chemistry.

LEARNING DIFFICULTIES ENCOUNTERED BY STUDENTS STUDYING THE CHEM STUDY PROGRAM

Ilene Joyce Swartney
State University College at Buffalo

The problem investigated in this study was to identify those science concepts and mathematical skills that may be the source of student difficulty in learning chemistry as described by the CHEMS program.

Although high school chemistry courses are somewhat selective by virtue of their reputation, there are many students who enroll who fail the courses. It is acknowledged that student failures may be due to lack of academic ability, lack of interest, lack of prerequisite knowledge and/or lack of mathematical and reading skills. Although these deficiencies are generally accepted, they do little to help understand what causes the student to fail. In this study, the concern is with the presence or absence of certain concepts and/or skills and student failure on tests in CHEM Study Chemistry. It is recognized that these deficiencies may be traced back to ability, interest, or other causes; however, their cause is not of concern; of concern is the consequence.

A clinical approach was utilized to determine if the students possessed the concepts and/or skills needed to respond acceptably to a test item. Each item on each test was analyzed to determine the concepts and/or skills necessary to give the desired response to that item. These concepts and skills became the topics discussed during personal student interviews held following each of the four tests. These interviews were conducted with those students who earned scores that ranked among the lower 20 percent in School A or the lower 30 percent in School B. The percent of the population was 30 percent in School B in order to include students with the same ranked scores from both schools. A fifth interview was developed which included the use of previously prepared interview questions selected from those that were answered incorrectly during the first four interviews by 50 percent or more of the students in either of the two schools. The students participating in this fifth interview were those who earned scores ranked within the top 20 percent of School A and the top 30 percent in School B on two out of the first three examinations.

Based upon findings within the limited population involved in this study, it appears that the students earning low scores on the CHEMS examinations were unable to define many technical terms, could not verbalize key concepts, did not possess the ability to solve simple algebraic equations, could not solve problems of a quantitative nature, and lacked the skills necessary to interpret graphs and charts. Specifically, the students did not understand or could not verbalize concepts with respect to the particulate nature of matter, equilibrium, temperature, energy and oxidation-reduction, as well as many others. These same difficulties were present to a limited extent among students who performed at a satisfactory level.

The following are some implications of this study. (1) It does not seem reasonable for the teachers of chemistry to assume that the common definitions used by students for common words as rate and boiling are the same as technical definitions when the terms are used in chemistry. (2) In planning curricula in chemistry it does not seem reasonable to assume that all students have a common background of scientific knowledge. (3) Some concepts, such as equilibrium and oxidation-reduction may be too rigorous for the high school student. (4) Teachers of chemistry should give special attention to concepts which deal with abstractions.

Concurrent Sessions G

Session G-1 New Instruments for Science Education Research

Chairman: J. W. George Ivany, Teachers College, Columbia University

1. "An Investigation to Develop an Instrument to Determine the Problem-Solving Skills in Science of Children in Grades One, Two, and Three," Maureen A. Dietz - University of Pennsylvania.
2. "The Development of the Test of Science Processes," Robert Sher Tannenbaum - Hunter College of the City University of New York.
3. "An Automated Analysis of the Structure of Programmed Science Materials," Milton O. Jacobson and Mary Ann MacDougall - University of Virginia.
4. "The Development of An Observational System Based on Piaget's Theory for Use in the Study of Experimental Problem Solving of Elementary School Children," Edward L. Smith - Cornell University.

AN INVESTIGATION TO DEVELOP AN INSTRUMENT TO DETERMINE THE PROBLEM-SOLVING SKILLS IN SCIENCE OF CHILDREN IN GRADES ONE, TWO, AND THREE

Maureen A. Dietz
University of Pennsylvania

The purpose of this study was to develop an instrument to determine the problem-solving skills in science of children in grades one, two, and three. The specific aims of the study were to identify the skills used in science problem-solving, to construct an instrument to measure these skills, and to determine the validity and reliability of the instrument.

The first step in developing this instrument was to carefully delineate the science content and problem-solving skills to be incorporated in the test. During the 1967-68 school year, about 1500 children in the first, second, and third grades were studied by this investigator. Basic tasks were selected to test the children's skills with respect to instruments, numbers, sameness, relative direction (right and left), and ordering by size. The children selected for this study were from three different types of school districts in and around Philadelphia, Pennsylvania.

With the knowledge of how first-, second-, and third-graders performed on these tasks, the investigator began constructing picture-problems. Seven such problems were shown to about 360 primary grade children. Taped recordings of the children's responses to the picture-problems were analyzed to determine if the children recognized the apparent inconsistancy (the problem) presented in the picture; if the children understood the function of the objects (see-saw, balloons, thermometers, bottles, fish tank, floating blocks) used to create a problem; and if the children could give at least one, if not more, reasonable explanation for what they saw happening in the picture.

Two parallel forms of the test were developed, with each form consisting of two physical science problems. Each problem is presented to the students in the form of a large picture shown to the class. The science problem is basically a manipulation of objects in a seemingly inconsistent way. The student answer booklet is divided in the following way.

Section 1

Here the student is asked to select one picture out of four pictures on the first answer sheet which shows the pieces of equipment as he usually sees them. By selecting any one of the four choices, the student indicates whether he does or does not recognize what is inconsistent about the large picture-problem. These choices were selected from oral explanations given by primary grade school children when they were presented with the picture-problems.

Section 2

In this section the student is presented with seven multiple-choice questions concerning the science concepts involved in solving the problem. The stem and choices of each question are in the form of pictures.

Section 3

Here the student is given an opportunity to collect data. Ten pictures are presented to the child. He is asked to "put an X under those pictures on his page that appear in the problem-picture." The picture choices on this page fall into three categories: (1) the picture choice on the child's page is a single element from the picture-problem; (2) the picture choices are combinations of the elements in the picture-problem; (3) the picture choices are not in the picture-problem.

Section 4

Four "if-then" picture choices are arranged on this last page of the student answer booklet. Here the student is directed to observe the first picture in each row. He is then asked to indicate which picture choice is correct if the original problem picture is changed to look like the first picture in the row.

Test Content

Each of the two parallel forms of _The Problem-Solving Skills Test_ contains two picture problems dealing with physical science principles. Form A, Problem 1, is concerned with heat expanding a liquid indicator in a thermometer and cold contracting this liquid. Form A, Problem 2, is based on the relationship of air pressure to liquids emptying out of a container. Form B, Problem 1, is concerned with the principle of a balance. Form B, Problem 2 employs the concepts of buoyancy and gravity.

The Problem-Solving Skills Test contains many limitations but the results obtained so far seem to indicate that it is measuring: (1) recognition of inconsistencies; (2) accuracy of visual observation; (3) reasoning with "if-then" statements; (4) understanding of science concept knowledge needed to solve a particular problem. Additional conclusions with respect to reliability, validity, and correlation of test scores with intelligence, age, sex, and years of schooling will be available in the final report ready in November, 1968.

THE DEVELOPMENT OF THE TEST OF SCIENCE PROCESSES

Robert Sher Tannenbaum
Columbia University

In this study, an instrument to assess achievement and diagnose weaknesses in the use of science processes by students in grades seven, eight, and nine was developed. It is entitled Test of Science Processes. The science processes considered were Observing, Comparing, Classifying, Quantifying, Measuring, Experimenting, Inferring, and Predicting. These were arrived at after a study of relevant texts and other literature. The original list was edited and condensed, and the behaviors which students must exhibit in order to demonstrate competence in the use of each of the processes were specified in detail. This statement of behaviors was submitted to experts for their opinions and validation before final writing. The final version of the statement of behaviors served as the blueprint for the Test of Science Processes.

The instrument has the following characteristics (1) It consists of 96 multiple choice (five choice) questions; (2) it requires total actual testing time of 73 minutes (some students may finish in less); (3) the test booklet is printed with black and white illustrations and, for the 12 questions which require color, 35 mm color slides are used; and (4) scoring of the instrument yields a total score (Kuder-Richardson formula 20 reliability = .91) and eight subscores, one for each process (reliabilities from about .30 to about .80).

The instrument was administered to 3,673 students from schools in the Bronx, New York, and Rockland County, New York. This sample was carefully selected to include all ability levels and a wide range of socioeconomic backgrounds. The results of this administration were used to create norms for total score and for each of the eight subscores. The norms are reported by grade, by sex, and by urban versus suburban, and for the total sample within each grade. The results were also employed in a study of the uniqueness of each of the subscores (i.e., the proportion of the non-error variance which is unique to that subscore). Six of the subscores were found to have uniqueness between .1244 and .1578. The other two subscores had uniquenesses which are not significantly different from zero, but this may be attributable to their short lengths. The item analysis data for all 96 questions administered to these students are reported.

There is considerable evidence of both the content and the curricular validity of the test. The criterion-related validity of the test is very difficult to assess because this is the first attempt to measure this age level students' ability to use science processes. A small investigation was undertaken to demonstrate the criterion-related validity (where the criterion is teacher rating of the students' abilities to use the processes). The results of this investigation were not unequivocal. However, they do give some indication of a degree of criterion-related validity. More conclusive evidence of this must await much more extensive investigations. The predictive validity of the Test of Science Processes has not yet been studied.

The report of this study consists of (1) an introductory chapter describing the study; (2) a chapter of suggestions for further study; (3) a copy of the Test of Science Processes; (4) the supplementary color pictures for the test; (5) a simplified instruction sheet for administering and scoring the test; (6) a comprehensive manual for the test; and (7) listings of all the computer programs used in the analyses.

AN AUTOMATED ANALYSIS OF THE STRUCTURE OF PROGRAMED SCIENCE MATERIALS

Milton D. Jacobson
and
Mary Ann MacDougall
University of Virginia

This paper presents an automated analysis of program structure which defines 25 independent variables descriptive of frame, response, and content presentation and organization variables and establishes the relationship of these variables with student performance. The automated procedures sort, locate, and accumulate a count and listing of the independent variables from the context of the programed materials. After a printout of the variable counts and word listings are obtained, the independent variables are related to student error rate (validated against student ability and achievement measures). The model of program structure is described by an equation of the best predictors of error rate. Descriptive data are summarized for all variables, those program variables significantly related to student performance are identified, and the nature of the relationship is established.

The automated analysis provides a comprehensive definition of program structure and an evaluative model of program adaptations. The use of such a model avoids the ambiguities often associated with program descriptions, such as Skinnerian, small step, etc., and extends the findings of program evaluation beyond a knowledge of success or failure to a statement of the nature of the influence of a program feature or branching modification. The analysis is suggested as an effective guide in the writing, revision and individual adaptation of programed materials.

THE DEVELOPMENT OF AN OBSERVATIONAL SYSTEM BASED ON PIAGET'S THEORY FOR USE IN THE STUDY OF EXPERIMENTAL PROBLEM SOLVING OF ELEMENTARY SCHOOL CHILDREN

Edward L. Smith
Cornell University

To fill the need for more complete reporting of subject's problem solving behavior in both laboratory and classroom studies, an observational system patterned after those of Flanders, Bellack, and others was developed. As a basis for selecting the categories for the observational system, a model of experimental problem solving behavior was developed based on Piaget's description of such behavior. The system differed from previous systems not only in its theoretical basis, but in its inclusion of non-verbal behavioral categories.

Descriptions of the categories and ground rules for the use of the system were prepared. An additional observer was trained and inter-observer reliability was estimated using the Scott Coefficient technique used by Flanders and others.

The system was used in a study of the relative effectiveness of external reinforcement and conflict in developing the ability to separate variables in fifth and sixth grade children. The data obtained allowed a determination of the extent to which each type of teaching conformed to the patterns described in the study. It also revealed changes in individual patterns of behavior unnoticed by the teachers during the teaching sessions. Tests were used at the conclusion of the study to indicate whether or not the children had learned to separate variables, but the data obtained with the observational system indicated when the learning took place, what activities preceded such learning, and how consistently the new behaviors were maintained.

Application of the system in a classroom setting is planned in a study of the relationship between knowledge of the concept of specific heat and the ability to separate variables in laboratory problem solving tasks involving the concept for nine to eleven-year-old children. The data obtained will be useful not only for evaluation of the laboratory lessons, but also will provide additional evidence on the validity of Piaget's descriptions of problem solving behavior in children of these ages.

Session G-2 The Structure of Knowledge and Science Education

Chairman: James Robinson, Teachers College, Columbia University

1. "An Interdisciplinary Theory of Behavior," O. Roger Anderson - Teachers College, Columbia University.

2. "Application of Thomas S. Kuhn's View of Science Teaching: An Exploratory Study," Walter S. Boldt - University of British Columbia.

3. "A Study of Formative Curriculum Evaluation Through the Use of Hierarchical Task Analysis," James Rusk Okey - Florida State University.

AN INTERDISCIPLINARY THEORY OF BEHAVIOR

O. Roger Anderson
Columbia University

The discussion presented in this paper will combine biological, biochemical, and psychological data toward the construction of a bio-psychological theory of behavior. Since the environment favored the evolution of organisms possessing receptors sensitive to periodic stimuli, these stimuli, through natural selection, induced the appearance of highly developed organisms which could react to the stimuli and thereby exploit the environment. The consequent dependency on periodic stimulation induced a psychological, perceptual bias to readily assimilate repetitive stimuli and thereby produce changes in behavior. As a result, the periodicity in environmental behavior of advanced organisms can be partially understood.

The fundamental role of periodicity in natural phenomena produced profound physiological effects on living organisms. Environmental periodicity, for example, induced the origin of photoreceptors containing chromophores sensitive to electromagnetic radiation and the development of the complex nervous systems of higher animals. It can be shown that as simple living forms evolved into more complex organisms, the structure and function of photoreceptors and of the nervous system concurrently increased in complexity. The elaboration of complex photoreceptros and the increasing mass of central nerve tissue are further specializations of a fundamental organic function induced by periodic stimuli early in phylogeny.

Since during maturation the human organism is repeatedly exposed to a succession of visual patterns, the organism develops a perceptual set predisposing him to perceive spatially contiguous bodies as having common properties. The constancy of association of proximate spatial bodies in successive retinal patterns further enhances the perceptual bias to perceive two spatially proximate bodies as having common properties. Given such a perceptual bias, the organism will readily assimilate serially ordered stimuli when these stimuli have common properties. Temporally contiguous responses, which are repetitively aroused, will become associated due to their homology to temporal relations of spatially related objects.

Thus learning is a process of response contiguity whereby repetitive arousal of responses occasions associations among responses. These associations are acquired during phylogeny and stimulated during ontogeny to readily assimilate repetitive or temporally contiguous stimuli.

This theory concludes that Guthrie was correct in his assertion that contiguity of responding rather than reinforcement is the salient requirement for associative learning. However, he did not propose physiological and phylogenetic bases for his conclusions. Moreover, an important criterion for human learning must be added; namely, maximum reception learning will occur when contiguous evoked responses contain common properties.

APPLICATION OF THOMAS S. KUHN'S VIEW OF SCIENCE TEACHING: AN EXPLORATORY STUDY

Walter B. Boldt
University of British Columbia

The study represents a preliminary stage in a long-term effort directed toward the development of a theory of classroom teaching and learning. The general problem investigated in the present study was the utilization of Thomas S. Kuhn's view of science--a theoretical view of the evolution of scientific knowledge based on historical, sociological, psychological, and philosophical considerations--for concepts and processes potentially useful for conceptualizing teaching-learning episodes.

The current national science curriculum revision movement has made it amply clear that a firm theory of classroom instruction based on classroom events is not yet apparent to those concerned with the problems of teaching science in schools. As a consequence, recommended instructional practices often tend to be vacuous. In the absence of such a theory, a number of attempts have been made to exploit theoretical frameworks, such as the Piagetian theory of cognitive development, as sources of concepts and processes for conceptualizing teaching-learning events. The present study represents an attempt to utilize a theoretical view of scientific knowledge that has emerged from the history of science as a source of ideas for teaching science. Hopefully, continued effort of this nature may eventually direct science educators toward acquiring a first firm research tradition in their field.

The general problem was resolved into four major parts, constituting four phases in the development of the study. The problem in the first phase was to examine Kuhn's writings for concepts and processes which are related to the growth and development of scientific knowledge and which were potentially useful for conceptualizing classroom events. In the second phase of the study, the problem was to obtain observational data illustrating concepts drawn from Kuhn's work. The problem undertaken in the third phase was to analyze and adapt the theoretical concepts, identified in the first phase of the study, to science teaching, and to illustrate the ideas adapted through apparent examples from the teaching-learning episodes observed. Finally, in the fourth phase of the study, the potential usefulness of the study for meeting certain problems in the teaching and learning of sciences was considered in a speculative way.

The writer speculated that the children in the study did display some paradigmatic-like behavior (individualistic styles for acquiring new knowledge which manifest perceptual-conceptual assimilations of past experience) in their investigations as conceptualized. Moreover, the writer felt that teachers, with some assistance, probably could identify paradigmatic behaviors among children in a classroom situation.

Taking a paradigmatic view of the children's attempts to abstract knowledge from their investigations of certain natural phenomena, the investigator felt that instructional difficulties related to certain scientific concepts may often occur because elementary school science teachers fail to realize that a number of prescience paradigm transitions, analogous to gestalt switches in perception, may have to be induced before a scientific concept can be introduced constructively. Furthermore, it appeared possible to link certain instructional prescriptions to explicit theoretical constructs in Kuhn's view of science.

Looking into the future, the writer sees, as a useful extension of the present study, the possibility of developing a sort of taxonomy of paradigmatic child behaviors employed in coping with particular natural phenomena, and with anomalous experiences likely to induce constructive paradigm shifts.

A STUDY OF FORMATIVE CURRICULUM EVALUATION
THROUGH THE USE OF
HIERARCHICAL TASK ANALYSIS

James Rusk Okey
The Florida State University

The traditional type of end-of-course evaluation is of limited value in improving the effectiveness of newly developed curriculum materials. What is needed is detailed information about student performance on small pieces of the curriculum while the materials are still in a developmental stage. Some of the recent curriculum efforts have used what is called a systems approach to instructional development. In the systems approach, outcomes are specified, means of attaining the specified outcomes are developed and tried out, and results are measured against expectations.

Robert Gagné has proposed a method for acquiring data to aid course developers in making revisions of their preliminary efforts. What is needed, says Gagné, is pass-fail information on each knowledge unit in a curriculum. The pass-fail data can be used to locate places of low student mastery and reveal the sequential dependence of units. By using the method, Gagné says curriculum design can be based upon empirical evidence rather than upon speculation or logical derivation.

In this research, the applicability of the Gagné evaluation method was studied by using it to gather performance data from students using an experimental science curriculum being developed by the Intermediate Science Curriculum Study at Florida State University. Specific behaviors required of the student were extracted from the curriculum materials, and student performance of these behaviors was assessed. In addition, a set of transfer items was used to see if students acquired a general capability on the behaviors judged to be important outcomes of the course. The outcome objectives were arranged in a hypothesized hierarchical sequence. Student pass-fail data on each pair of objectives in the sequence were used to locate places of low mastery and sequence reversals. A place of low mastery is defined by a drop in achievement from one task to the next. A sequence reversal is defined as the phenomenon in which more students master a higher than a lower task in a hypothesized sequence.

The student performance data collected in the study were presented to the curriculum writers for each chapter of the materials evaluated. The information provided the writers contained the student performance data on each specific behavior and each outcome objective. Other information presented included a correlation of IQ and achievement for all test items, location of places of low mastery and sequence reversal, a categorization of the wrong student answers on each behavior and objective, and a set of recommendations based on the data.

To aid in deciding the value of the Gagné evaluation method, the writers were not given the data from a portion of the analyzed materials. The revisions in the materials for which student data has been provided were compared with the changes in the materials revised on a conventional basis. The intent was to determine how and to what extent the curriculum writers had used the data. Major changes were made in the materials for which recommendations were provided although not all of the recommendations were followed.

In this study, the Gagné evaluation method was judged to be a valuable component in the systems approach to instructional development. Employing the evaluation method allowed an assessment of the effectiveness of curriculum materials and provided precise, detailed, empirical data that were valuable in making revision decisions.

Concurrent Sessions H

Session H-1 Survey of Research in Science Education

Chairman: Robert W. Howe, The Ohio State University

1. "DISCUS, A Demonstration of an Improved Science Curriculum for Underachieving Students," N. Eldred Bingham, C. Robert Cronin, and Larry Paulk - University of Florida
2. "Research Studies in Science Education: 1948-1952," J. Nathan Swift - State University College, Oswego, New York
3. "Research Studies in Science Education: 1953-1957," Elizabeth Phelan - Hunter College of the City University of New York.

DISCUS, A DEMONSTRATION OF AN IMPROVED SCIENCE CURRICULUM FOR UNDERACHIEVING STUDENTS

N. Eldred Bingham
University of Florida

C. Robert Cronin
DISCUS

Larry Paulk
DISCUS

Concern for improving the attitudes of educationally deprived underachieving youth toward their teachers and toward their schools motivated the authors and their associates to carry out a pilot investigation to test (1) whether such youth need preferential treatment if they are to profit from their school years, and (2) whether science can serve as a vehicle for this preferential treatment.

After completing the pilot project, the authors initiated a larger and more comprehensive project entitled "DISCUS - A Demonstration of an Improved Science Curriculum for Underachieving Students." Funded under Title I of the ESEA, Project DISCUS is designed to involve educationally disadvantaged underachieving youth in a carefully planned special program of science at the seventh, eighth, and ninth grade levels. This extended program is presently being implemented in fourteen junior high schools in Duval County, Florida. These schools were randomly selected from those schools having the highest percentage of educationally deprived underachieving youth. In the fourteen selected schools, 54 teachers volunteered to participate in DISCUS, of which 27 were randomly selected to be in the experimental program and 27 to be used as controls. The original course materials were rewritten and expanded to include a seventh grade biological science program, an eighth grade physical science program, and a ninth grade earth science program. In the 1967-1968 school year, Project DISCUS was in operation for a period of 14 weeks. Pretests were administered in January and post-tests the following May, and complete test data were obtained for 850 students in the experimental group and for a similar number in the control group.

Among the tests used in the project were (1) the Otis Quick-Scoring Mental Ability Test: New Edition, Beta Test, (2) STEP, Sequential Test of Educational Progress, Science for grades 4, 5, and 6, (3) The Battle Student Attitude Scale, and (4) projective interviews. In assessing the beliefs, feelings, and attitudes of these students, it was felt that since they relied less on students' ability to read and write, the projective interviews identified more significant changes in attitude than did the written instruments.

Based on the analysis of objective data and based on subjective evaluation of staff observations and teacher anecdotal records, the following conclusions were established in this demonstration-research project. (1) A preferential treatment of educationally disadvantaged junior high school students in success-oriented science classes does improve their attitudes toward school personnel and toward the school.

(2) Without a hospitable class environment such as that provided in the DISCUS project, the students' attitudes toward school personnel and toward school deteriorate; the students figuratively "drop out" of school until they can legally "drop out." (3) Involvement in small group meaningful laboratory activities in which the students generate data, communicate about the data, and use the data in developing concepts does enable educationally disadvantaged underachievers to continue to develop in school. (4) Even as late as during the junior high school years it is possible to rehabilitate educationally disadvantaged underachievers who are potential dropouts.

The authors feel there is reason to be very optimistic about the results that will be procured from a student of DISCUS Project as it is being conducted during the current school year and as it is planned for 1969-1970.

RESEARCH STUDIES IN SCIENCE EDUCATION: 1948-1952

J. Nathan Swift
New York State University College at Oswego

The problem investigated in this study was to select the most significant research studies in science education for the period 1948 through 1952 and to prepare digests of those publications.

Investigations in science education are reported in a variety of journals and books, some of which are not readily accessible to practitioners, laymen, and science education research workers. This study has been prepared to serve as a guide to research in science education and to make the results of the research more readily available.

Francis D. Curtis, in his first, second, and third digests of investigations in the teaching of science, collected and abstracted selected research studies in science education from 1910 through 1937. His much commended work was continued by Dr. Robert Boenig for the period 1938 through 1947. In 1957, the federal government began abstracting publications in science education. This work, along with a subsequent study, bridges this intervening time span.

Procedures similar to those of Dr. Curtis and Dr. Boenig were employed in this study. All studies that might possibly be included were located by literature searches that involved several cross-checks. The long lists that resulted were shortened by the elimination of repetitive titles and studies not involving research. Annotated bibliographies were prepared for submission to 14 science educators who were active as researchers during 1948 to 1952. Studies deemed by the evaluators as being most significant were prepared in digest form; those of lesser merit were included as annotated bibliographical entries.

The evaluators were free to choose as many or as few studies as they thought were worthy of preparation as digests. The average number chosen was 40. Therefore, the 40 studies receiving the highest scores were selected. An additional 12 with scores near this value were also included. Duplications and combinations reduced this number to a final group of 44 digests.

In this volume, seven of the digests were on the elementary education level, 21 were at the secondary level, and 16 at the college level. The 100 annotated entries included nine at the elementary level, 37 at the secondary, and 54 at the college level.

When categorized with reference to the nature of the studies, 11 digests were concerned with the nature of pupils, 11 were about the nature of teachers, ten were concerned with content, six with cognitive variables, and four with test construction. The annotated entries for each of these topics were found to be 21, 15, 26, 18, 8, and 10 respectively.

This volume is to be published soon by Teachers College Press, Columbia University, New York.

RESEARCH STUDIES IN SCIENCE EDUCATION PUBLISHED DURING 1953-1957

Elizabeth Phelan

In 1924 Dr. Francis D. Curtis, realizing the information retreival difficulty faced by students and researchers in Science Education, published a digest of all studies in Science Education produced between 1900-1924 which met his stated criteria and therefore qualified as research studies. This first volume included 70 digests. The volume was intended to be both a secondary source for researchers and a textbook for training students in research methodology.

Even before publication, it was apparent to Curtis that there had been many studies which should have been included in this first volume. To help solve this problem, Curtis requested the members of NARST to compile a list of both published and unpublished research investigations which related to any phase of the teaching of science. This list was to include any investigation which a member considered to possess sufficient significance to warrant inclusion in a second volume of compiled investigations. From this list he compiled a very lengthy bibliography, and sent this list back to the NARST members to vote on the merit of individual studies. Those 92 studies which received the highest score were included in the second volume of digests. This volume covered the whole period from 1900 to 1929.

The problem which makes a continuation of this series difficult was apparent even at this early stage. The methods used to compile volume one and volume two were very different. In volume one, a single scholar applied his own stated criteria in order to identify research studies; in volume two, a greater number of men applied their own unstated criteria for "significance" as well as for "research." Volume three, also compiled by Curtis, followed the procedure of volume two. This volume, covering the period 1930-1936, contained 93 digests.

The Curtis series was continued by Robert Boenig whose work covered the period 1938-1947. In compiling a bibliography, Dr. Boenig did not include unpublished studies. He used his own criteria for identifying a study as research, and he used frequency of citation over a ten-year period as an indication of significance. He used a jury of NARST members to select from the bibliography 79 studies which he digested in volume four of the series. Again there was no way of knowing what criteria were used by the various members of the jury to rate the studies. Volume five of the series was completed by J. Nathan Swift. This volume covered the period 1948-1952.

The evolution of methodology used in selecting studies for inclusion in the series in an "abstract" form epitomizes the dilemma faced by anyone attempting to continue a series of scholarly studies. There is, on the one hand, a need to preserve continuity, and, on the other hand, a need to re-examine the methodology of one's predecessors in the light of contemporary standards. In science education we badly need both continuing series of related investigations and the maintenance of improved methodology. Both of these elements are essential for progress. How this dilemma was faced and solved in one case is the subject of this paper.

In the present volume of the series, the value of the jury was the most critical element. The selection of and application of criteria for identifying "research" and for determination of "significance" were additional problems.

The problems were solved by (1) the choice of a definition of research from the standards developed by the USOE; (2) the application of the standard to all published science education studies in the 1953-1957 period; (3) the abstraction of all studies selected by this method; (4) the use of "citation" as a clue to find omitted studies but not as a criterion for elimination of studies; and (5) the "jury method" to select certain studies for more complete treatment as "digests" and to discover omitted studies. Under the last point, the jury was given a set of criteria for their ratings. The ratings were subsequently trichotomized and only those studies which were unambiguously voted as useful and known to more than one-half of the judges were included in the more lengthy "digest" form.

The number of studies abstracted was 137, and the number of digests was 33. The studies were classified along two lines: by educational level and by independent and dependent variables considered. In general, the research published during the 1953-1957 period was heavy on the high school and college levels and concentrated on such variables as pupil beliefs and attitudes, problem solving, and teaching methods.

Session H-2 On the Teaching of the Physical Sciences

Chairman: Robert E. Lepper, California State College, Fullerton

1. "The Development and Evaluation of Materials Based on Piaget's Theories on Logical Thinking for Use in Instruction on Formulating Equations in Physics," Earl J. Montague - University of Texas

2. "Processes and Structure of the Physical Sciences for School Curricula," Clinton St. John - Ontario Institute for Studies in Education

3. "Expository-Deductive vs. Discovery-Inductive Programing of Physical Principles," R. Thomas Tanner - Oregon State University

THE DEVELOPMENT AND EVALUATION OF MATERIALS BASED ON PIAGET'S THEORIES ON LOGICAL THINKING FOR USE IN INSTRUCTION ON FORMULATING EQUATIONS IN PHYSICS

Earl J. Montague
The University of Texas

Physics students as well as physics teachers have long experienced difficulties with the extensive quantitative thinking called for in the subject. This study explored the possibility of partially overcoming such difficulties through the use of instructional materials based on the research of Jean Piaget. Piaget has developed the theory that the growth of an individual's logical thought about physical phenomena progresses heirarchically from the child's first unsystematic manipulation of things, through a stage in which the child reasons from a basis of his actions with the things, to a stage of formal thinking in which the adolescent reasons logically about truly abstract variables. Quantitative thinking in physics must clearly be placed near the top of this hierarchical ladder.

In this study, the assumption was made that instructional sequences on quantitative thinking about physical phenomena, at least for cognitively immature students, should, so far as is feasible, parallel the sequence of development of the child's ideas as developed by Piaget.

This study involved the development and evaluation of three self-instructional episodes for use in ninth-grade physical science classes. Each episode was closely based on Piaget's analysis of the spontaneous logical development of the child concerning the particular physical phenomenon of the episode. Each episode began with the student's actions with physical apparatus and proceeded to the formulation of a mathematical equation representing the phenomenon of the episode. The episodes were entitled:

(1) Equilibrium in the Balance; (2) The Oscillation of a Pendulum; and (3) Hauling Weight on an Inclined Plane.

The self-instructional episodes were evaluated through a classroom trial with 133 ninth-grade physical science students. Data were collected on pre- and post-test administrations of a test designed to measure attainment of specified objectives. Evidence for evaluation was also collected from students' written responses on the self-instructional episodes themselves.

The following are the results of this study.

1. On the Balance section of the pretest, most of the evaluation sample exhibited comprehension of specified qualitative rules involving symmetry conditions for equilibrium in the balance, a schema for compensation in order to restore equilibrium in a balance, and a qualitative rule to the effect that the heavier the weight, the closer to the middle of the balance it must be placed for equilibrium. Slight improvement from pretest to

post-test on items relating to the qualitative rule seems to indicate that the Balance Episode was successful in leading many of the remaining students to a comprehension of the rule.

2. A relatively large improvement from pretest to post-test in comprehension of the equation for equilibrium in the balance seems to indicate that the Balance Episode was successful in leading students to the equation.

3. Students on the pretest were generally not successful in excluding weight and angle as factors affecting the period of a pendulum. A large improvement on the post-test relative to this exclusion indicates that the Pendulum Episode was successful in leading students to exclude the angle and the weight. There is some indication from student responses on the episode booklets that students had difficulty with the logical analysis of data necessary for the exclusion of weight and angle.

4. Prior to instruction a large percentage of the students knew that a change in the length of a pendulum causes a change in the period. A slightly smaller percentage knew that the change is such that an increase in length leads to an increase in the period. Few students appeared to know, either prior to instruction or after instruction, that the square of the period is proportional to the length of the pendulum. The episode was evidently not successful in leading students to comprehend this quantitative relationship.

5. The Inclined Plane Episode appears to be relatively successful in leading students to comprehend the qualitative relationships between the weight on a plane, the counterweight attached to it, and the inclination of the plane. The episode was not very successful in improving comprehension of the quantitative relationship between the weight on the plane and the counterweight, although a large percent of the sample appeared to know this relationship before instruction.

6. Both before and after instruction students thought that the counterweight is proportional to the angle, rather than to the sine of the angle, of the inclined plane in equilibrium situations. The Inclined Plane Episode attempted explicitly to dispel this erroneous notion, but was not successful.

7. There was considerable improvement from pretest to post-test on comprehension of the equation for equilibrium of a truck on an inclined plane. However, because exclusion of the angle as a quantitative factor and comprehension of the equation for equilibrium are closely interrelated and because students were not successful in excluding the angle, one cannot conclude that instruction on the equation was successful.

In summary, each of the episodes was successful in leading students through the qualitative stages leading to the equation involved. It was found that the episodes were quite successful to the extent that they followed Piaget's analysis of the logical development of the child. In dealing with the Inclined Plane and the Pendulum, it was necessary to go beyond Piaget's findings in order to develop the quantitative relationships. In these cases the self-instructional episodes met with little success. This model for the development of curriculum materials based on psychological theory has definite implications in the area of science education.

PROCESSES AND STRUCTURE OF THE PHYSICAL SCIENCES FOR SCHOOL CURRICULA

Clinton St. John
University of Toronto

The current emphasis in science curriculum construction is on the processes of inquiry used by scientists and the structure of science. At the present time there are few descriptions of processes and structure which are in a form readily usable by the curriculum builder or the curriculum evaluator. It is the intent of this study to develop a set of behavioral objectives and other representations which are indicative of (1) the processes of inquiry used by physical scientists, (2) the components which make up the structure of the physical sciences, and (3) the relationships among these various processes and components. The purpose of these objectives and representations is to function as checklists and be suggestive of topics and activities for the construction, modification, and evaluation of curricula which aim at emphasizing the structure of science and the processes of scientific inquiry.

Science, like most other objects of man's attention, has not escaped dualistic description. Science is conceived as being comprised of a content and a method. This conceptual dualism seems to have little basis in fact, since practicing scientists are unable to divorce the one from the other. Scientific content and scientific method are inextricably wedded through definition; for whenever scientific content is produced, the method used for its production is proclaimed as being part of the method of science.

Profitless as this content-method dualism may be for science, it has a definite utility when applied to the teaching of science. Education, whether in science or in any other discipline, is not primarily concerned with developing new knowledge. In education there is no analogical necessity for content to be functionally related to method in the way that it is in science. Science content has been taught using methods which are very different from the methods of science. It is this separation of content and method which is condemned by many persons interested in the improvement of science teaching and which is seen by them as both a distortion of science and a hindrance to learning. The separation of content and method should be minimized, and it is hoped that the results of this study will help bring content and method closer together.

The research design involves the content analysis of a random sample of fifty books which have been written by scientists and philosophers of science and which deal with the general subject of the nature of science. Statements about science were first identified and then grouped and summarized according to topic and the ideas expressed within a topic. This summary was then used as the basis for deriving a list of activities engaged in by scientists (these imply behavioral objectives), a list of the components of science and their definitions, and a set of diagrams depicting some of the relationships among the various processes and components. Applied were some tests which indicated that the content analysis procedures as performed by the researcher were sufficiently reliable. A test for completion demonstrated that the number of different ideas encountered in the sample was sufficiently comprehensive.

The findings of this study consist of a series of five summaries which present science from different vantage points. The first summary (components of science) depicts science as a group of concepts which are used to describe classes of constructions and statements used in science. The second and third summaries (assumptions of scientists and rules of scientists) refer to the assumptions made by scientists in their work and which, therefore, permeate much of science. The fourth summary (relational diagrams) presents science from the standpoint of the relationships among its various components and procedures. The fifth summary (activities of scientists) lists the activities engaged in by scientists as they endeavor to create scientific knowledge.

For the results of this study to be useful in curriculum development it is assumed that the curriculum under consideration has a significant, if not a primary, commitment to the processes of inquiry and the structure of science. To the extent that this commitment is recognized, and to the extent that this study is successful in fulfilling its purpose, it is believed that the findings and construction herein reported will prove useful to curriculum developers and curriculum evaluators. The findings can serve as (1) the bases for suggesting curricular units and activities, (2) a checklist of objectives for comparison with the behavioral objectives of an existing curriculum, (3) the starting point for the establishment of an empirically determined hierarchy of behaviors, and/or (4) the basis for constructing instruments for evaluating pupil progress.

EXPOSITORY-DEDUCTIVE VS. DISCOVERY-INDUCTIVE PROGRAMMING OF PHYSICAL SCIENCE PRINCIPLES

R. Thomas Tanner
Oregon State University

Research in discovery learning does not lend strong or consistent support to the current proposition that much learning in science should be discovery-inductive in nature. This experiment is an attempt to control variables which may have confounded the results of previous studies in this area.

Three forms of a highly illustrated self-instructional program were used to teach principles of mechanics to 360 ninth-grade students in fourteen general science classes. These programs constituted three experimental treatments, each offering a different degree of guidance to the learner. In the Expository-Deductive program, explanations of principles preceded example frames illustrating the principles. The Discovery-Inductive and Unsequenced-Discovery programs contained only the example frames, which were randomly ordered in the latter program. In these two programs, the learner had to infer the principles if he were to attain them at all. All programs contained the same questions and feedback. The three treatment programs were distributed randomly and in approximately equal numbers in each class.

The use of these programs as treatments allowed control over confounding variability in assignment of subjects, experimental history, time, novelty, learner activity, teacher traits, medium of instruction, content, class discussion, and feedback.

Criterion measures of comprehension, lateral transfer, vertical transfer, retention, and interest were administered. Data were subjected to analyses of variance and covariance.

No significant main effect difference was found for any criterion measure. However, some interactions of treatment with sex and with intelligence were noted.

Future research should include experiments which (a) consider the interaction of treatment and content with subtle organismic variables, (b) are well controlled but of longer treatment duration, (c) allow subjects to become accustomed to discovery-inductive methods prior to the administration of treatments, and (d) use dependent variables specifically related to the science curriculum.

Concurrent Sessions J

Session J-1 The Use of New Approaches and Materials in Science Instruction

Chairman: Jacob W. Blankenship, Oklahoma State University

1. "The Construction and Evaluation of a Programed Course in Mathematics Necessary for Success in Collegiate Physical Science," Robert B. Collagan - Morgan State College
2. "An Evaluation of a Secondary School Physics Course Taught Via an Audio-Tutorial Mode," Michael Szabo and J. William Asher - Purdue University
3. "Programed Instruction Materials in Science for Local School Use--An Approach to Their Evaluation," Seth F. Wohl - New York City Bureau of Curriculum Development

THE CONSTRUCTION AND EVALUATION OF A PROGRAMED COURSE IN MATHEMATICS NECESSARY FOR SUCCESS IN COLLEGIATE PHYSICAL SCIENCE

Robert B. Collagan
Morgan State College

Success in college is frequently predicated upon the early mastering of mathematical skills. However, freshmen with a deficiency in mathematics frequently demonstrate, concomitantly, a deficiency in English. Since conventional instruction in collegiate mathematics depends upon an advanced capability in reading skills, the student faces an immediate dilemma in his inability to read conventional textbooks in mathematics.

The primary problem in this research was to develop a programed mathematics text that would teach that mathematics essential to the successful manipulation of quantitative problems in the physical sciences, minimize the importance of reading in the teaching of such mathematics, and emphasize the significance of mathematics not as an abstraction, but rather as it specifically relates to problems in the physical world.

The general purposes of the study were twofold: first, to determine whether a programed course in mathematics better prepared non-science majors in that mathematics essential to a quantitative understanding of science than did a conventional program of the same duration and subject matter emphasis; and second, to determine whether those students who had completed the programed course performed better in a physical science course than those who had taken the conventional course in mathematics.

A 504 page programed mathematics text was written, reproduced, and distributed to 77 students who comprised the experimental group, while the matched pairs which made up the control group used a conventional mathematics text. After ten weeks of mathematics instruction, six weeks of teaching in astronomy, and eight weeks of physics instruction, the following hypotheses were accepted on the basis of the evaluation of differences between experimental and control groups as measured by z-ratio techniques:

1. The level of learning of mathematics by the control group increased with conventional instruction.

2. The level of learning of mathematics by the experimental group increased with programed instruction.

3. The level of learning of mathematics by the experimental group exceeded that of the control group.

4. After conventional mathematics instruction, the control group's level of learning of physical science increased with conventional instruction in astronomy and physics.

5. After programed mathematics instruction, the experimental group's level of learning of physical science increased with conventional instruction in astronomy and physics.

6. The level of learning of physical science by the experimental group exceeded that of the control group.

Not only did the experimental group exceed the control group in learning levels of both mathematics and physical science, but also they completed the prescribed mathematics subject matter course in less time than the control group.

On the strength of the research results, it has been recommended that the programed course be widely adopted for use with those college students exhibiting needs for remediate instruction in English and mathematics.

AN EVALUATION OF A SECONDARY SCHOOL PHYSICS COURSE TAUGHT VIA AN AUDIO-TUTORIAL MODE

Michael Szabo
J. William Asher
Purdue University

The purpose of this study was to determine whether audio-tutorial (a-t) instruction was as effective for teaching high school physics to juniors and seniors as conventional instruction.

This study, therefore, (1) attempts to establish some methodological precedents in the area of a-t evaluation consistent with Scriven's model for curriculum evaluation, (2) determines the general overall effectiveness of the a-t mode of instruction in comparison to a conventional mode of classroom physics instruction, and (3) attempts to identify assessable characteristics which are predictive of academic success in a-t physics.

During the 1967-1968 school year, two classes of juniors and seniors formed an experimental group in an a-t approach to teaching physics in a large Midwestern high school.

A control group, composed of physics students from the 1966-67 school year who were enrolled in a conventional physics course, was used in the study. The groups were found to be equivalent on the basis of scores on seven available predictors.

Separate multiple regression analyses were run on the a-t and control groups using the Weighted Regression Analysis Program (WRAP) on the IBM 7094 computer at Purdue University.

The standard course and the a-t instruction groups were then compared on the basis of a two-part standardized final examination and course grade using "t" tests for differences between means. No significant differences were found.

In the next phase of the evaluation, attitudinal and personal information questionnaires were administered to all students. Additional data were secured from school records.

Using geometry grade, fourth semester grade index, and PMA scores as predictors, and course grade as the criterion, the WRAP analysis yielded a multiple regression equation for each group. This analysis yielded a multiple R^2 of .80 for the control and .31 for the a-t group. The multiple R^2 is regarded as the amount of variance in the criterion accounted for by the predictor(s).

The students did not differ significantly on course grade, nor on parts I and II of a standardized final examination. However, the questionnaire showed a markedly higher enthusiasm for the a-t method of physics instruction compared to the standard method of instruction.

The large difference between the multiple R^2's for the two groups is interpreted as reflecting the presence of factors important for academic success in a-t physics, but not for the control groups. One might ask,"What are the variables which will account for maximal prediction under an a-t system?"

In addition to the large discrepancies found between the multiple R^2's, the two sets of predictor variables which are significant in predicting course grade had only one member in common, the fourth semester grade index.

The fact that the group means were not different for course grade may indicate the success of the a-t approach. Students in a first-year, new approach to teaching physics performed as well as students enrolled in a course taught in a well established, fully tested manner.

In the light of these findings, further evaluation is being done. One hundred students have been randomly assigned to either one of three a-t or two control classes for the 1968-69 school year. Two teachers are participating, and the search for adequate predictor variables is being expanded into the realm of personality and socio-economic measures.

PROGRAMED INSTRUCTIONAL MATERIALS IN SCIENCE FOR LOCAL SCHOOL USE

AN APPROACH TO THEIR EVALUATION

Seth F. Wohl
Columbia University

The problem investigated in this study was to determine how programed instructional materials in science can be evaluated by science teachers and supervisors for local use.

Documented under-utilization of self-instructional materials in science, when emphasis on individualization is increasing, suggests giving faculties "guidelines" so that they can better exploit currently available technology.

Such "guidelines," specifically applicable to science education, were absent from the literature.

Guidelines* were developed the same way as programed instruction--empirically, through experiences of local faculty teams in working with six aspects of the problem: (1) locating available programed materials, (2) determining criteria for their selection, (3) evolving rapid procedures for locally revalidating them with small student samples, (4) simplified data procedures from these initial tryouts, (5) generating the Guidelines, and (6) evolving suggestions for their implementation.

Use of standard bibliographies helped locate several hundred commercially available programed science materials.** Observable "internal" and reportable "external" criteria were listed for 100 programs, and 13 of these were selected as potentially applicable to the local curriculum if revalidated.*** Revalidation with only three students per class became feasible under multiple class replication, and teacher aptitude ratings correlated with standardized science achievement scores. A six-step "learning cycle" procedure was observed for students. Guidelines were evolved from these findings and three principal concerns of local program users: (1) need for a resource person helping teachers work more effectively with programed materials, (2) ready evaluation of individual learning achievement, and (3) relevance of selected self-instructional units to the local science curriculum.

It is feasible to develop guidelines empirically by using few students in local preliminary "revalidation" tryouts with programed science materials. Effectiveness appears contingent upon coordinating activities of a resource person to standardize selection and individualized study, to allocate materials, and to insure adequate implementation of revalidated programs.

These *Guidelines* are uniquely different from earlier attempts by its empirical base, its wider range of administrative curricular and implementation provisions, and its detailed operational specifications for programed individualized study.

Flexible design suggests broad applicability of these *Guidelines* beyond science to other disciplines in education and industry.

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*The *Guidelines* appear as an Appendix in the dissertation, "An Approach to the Evaluation of Programed Instructional Materials in Science for Local School Use" by Seth F. Wohl, Teachers College, Columbia University, 1968, pp. 357-389. The study is available from University Microfilms, Ann Arbor, Michigan

A mimeographed copy of the *Guidelines* alone under the title, "Guidelines for Implementing Programed Instructional Materials in Science," will be made available upon receipt of $1.00 to the author at Box 129, Teachers College, Columbia University, New York, New York 10027.

**Carl H. Hendershot, *Programed Learning: A Bibliography of Programs and Presentation Devices*, 4th ed., published by Carl H. Hendershot, Bay City, Michigan. *Programed Instruction Guide*, Newburyport, Massachusetts: Entelek, Inc., 1967 (Computer-compiled).

***Joint Committee on Programed Instruction and Teaching Machines "Criteria for Assessing Programed Instructional Materials: 1962 Interim Report," *Audiovisual Instruction*, Vol. 8, No. 2 (February, 1963)), pp. 84-89.

Session J-2 Teaching and the Development of Teaching Competencies

Chairwoman: Mary Budd Rowe, Teachers College, Columbia University

1. "A Comparison of the Teaching Behaviors of Second Grade Teachers Teaching Science - A Process Approach with Second Grade Teachers Not Teaching a Recently Developed Science Curriculum," Gene Hall - University of Texas

2. "A Comparative Study of the Effect of Practice With Elementary Children or With Peers in the Science Methods Course," Alan Henry Steinbach - St. John's College

3. "Science Teachers' Self Analysis in the Area of 'Discovery'," Frank X. Sutman - Temple University; Patricia Sparks - Stamford (Conn.) High School

4. "A Comparison of the Effectiveness of An Inservice Program and a Preservice Program in Developing Certain Teaching Competencies," Frank D. Breit and David P. Butts - University of Texas

A COMPARISON OF THE TEACHING BEHAVIORS OF SECOND GRADE TEACHERS TEACHING SCIENCE - A PROCESS APPROACH WITH SECOND GRADE TEACHERS NOT TEACHING A RECENTLY DEVELOPED SCIENCE CURRICULUM

Gene E. Hall
The University of Texas

A new awareness and concern for the improvement of science instruction in American schools has recently evolved from the scientific and technological developments following World War II, the Korean Conflict, and, more recently, Sputnik. During the late 1950's and early 1960's, following the revision of secondary science curricula, drastic revisions were made in existing elementary science programs. In addition, during the past five years a concern for the improvement of science instruction in the elementary school has resulted in the development of several "new" elementary science curricula (e.g. AAAS Science - A Process Approach; Science Curriculum Improvement Study; and the Minnesota Mathematics and Science Teaching Project.)

Although the training of teachers has been of concern to all curriculum developers, very little empirical evidence is available demonstrating differences and/or similarities in the classroom behaviors of teachers using contrasting curricula. There have been some empirical examinations of teacher classroom behaviors while teaching the recently developed science curricula. Nevertheless, many questions have not been adequately answered. For example: Do teachers using a recently developed curricula differ from teachers using traditional materials in their teaching behaviors? Do summer workshops result in significantly different teaching behaviors than in-service programs? Does a visiting consultant influence teaching behaviors differently than the curriculum specialist from within the school system?

Using the background and rationale stated above, this study will attempt to examine the following questions:

If a school system installs a recently developed curriculum, does this curriculum in and of itself influence teaching behaviors and do teachers teaching this curriculum exhibit different teaching behaviors than teachers not teaching a recently developed curriculum?

What effect does the method of teacher training and supervision have on the teaching behaviors of teachers teaching a new curriculum? What teaching behaviors of new curriculum teachers may be attributable to the in-service method of teacher training and the presence of a school system curriculum specialist throughout the school year? What teaching behaviors of new curriculum teachers may be attributable to a summer workshop method of teacher training and the presence of a curriculum specialist from outside the school system during the school year?

The curriculum vehicle chosen for this study was Science - A Process Approach. Three groups of eight second grade teachers were selected from a sample of upstate New York suburban teachers.

Groups SuS and InS were teaching Science - A Process Approach for the first time. SuS teachers were introduced to Science - A Process Approach in a five-day summer workshop which included training similar to that received by the AAAS tryout teachers. In addition, these teachers had a biweekly visiting science consultant throughout the school year. Group InS was trained in a series of in-service sessions during the school year prior to the official installation of the curriculum and received supervisory help from their school system K-12 science coordinators. Group NoS teachers were not trained in teaching a recently developed science curriculum. NoS teachers were teaching similar science programs to those the SuS teachers taught in previous years.

Three observations of each teacher were made by three different observers using the Instrument for the Analysis of Science Teaching (IAST), developed specifically for this study by the investigator. The IAST consists of two parts: Part I is a 26-category system of interaction analysis, and Part II is a 15-item sign system which the observer completes at the end of each observation period. Observer reliability estimates made during the data collection period ranged from .705 to .867 with a mean value of .772.

One-way analysis of variance and post-hoc comparisons were employed in the statistical analysis of the IAST data. The following differences were found in the teaching behaviors of the three groups: Group SuS differed significantly from Group NoS in their:

use of more teacher management information and direction statements
student overt activity
teacher talk per amount of student talk
teacher closed questions per number of open questions

use of fewer teacher open questions
student open statements
extended student talk per amount of transition student talk
extended student talk per total amount of student talk

Group InS differed significantly from Group NoS in their:

use of more teacher management information and direction statements
student overt activity
direct motivation and control teacher behaviors

use of fewer student closed statements
student open statements
extended student talk per amount of transition student talk
extended student talk per total amount of student talk

Two principal conclusions drawn from this study are:

(1) teachers teaching Science - A Process Approach do have some different teaching behavior from teachers not teaching a recently developed science curriculum, and (2) the five-day summer workshopand biweekly visiting science consultant were more effective than in-service training during the school year and supervisory help from the K-12 school system science coordinator for installing Science - A Process Approach.

A COMPARATIVE STUDY OF THE EFFECT OF PRACTICE WITH ELEMENTARY CHILDREN OR WITH PEERS IN THE SCIENCE METHODS COURSE

Alan Henry Steinbach
St. John's College

Pre-student teaching practice opportunities have been recommended in the pre-service training of elementary teachers. These opportunities should be oriented to the laboratory point of view so that the application of the principles suggested in the instruction courses may be carried out with a minimum of concern for classroom management.

One-to-one and one-to-two teaching provides such practice for the pre-service teachers with one or two pupils for fifteen or twenty minutes. Feedback is supplied by experienced teachers so that reinforcement is provided on the way in which these principles apply to a teaching situation. Such a system of practice and feedback was implemented in the science methods course for pre-service elementary teachers at the University of Texas.

Elementary children are not always readily available to provide such practice opportunities during the methods courses, and the contribution of peers to such practice is not known. This study examined the impact of feedback and compared practice with children or with peers in the attainment of specific teaching competencies. It compared the competencies achieved and the change in attitude of these prospective teachers as a result of varying combinations of practice, feedback, and grade level. These specific competencies were identified as maintaining teacher-pupil interaction, developing teacher-pupil rapport, pacing the lesson, presenting the lesson with clarity, and using behavioral objectives.

The subjects of this study were thirty-one pre-service elementary education majors. Sixteen of the subjects were assigned to teach children in the low-ratio setting at Lucy Read Elementary School in Austin, Texas, while the other fifteen taught their fellow peers from the science methods course at the University of Texas. Lesson materials that would provide a challenge to peers and children were provided from Science - A Process Approach.

A semantic differential, interaction analysis, and rating scales of teaching performance were utilized on a pre and post basis. The performance data were collected from videotapes of the teaching sessions. Using a three factorial analysis of variance to determine the effects of type of practice, feedback, and grade level on attitude and on the specific teaching competencies, the investigator noted the following findings:

1. Practice with peers or with children made little difference. Except for specific interaction and pacing skills in regard to questioning techniques and clarification of student ideas, there were no significant differences in attitude changes and these five specific teaching competencies between those who taught children and those who taught peers.

2. Systematic feedback provided significant results. Systematic feedback was found to be essential in the development of skills associated with pacing and with clarity of presentation, but was not found to be essential in the development of interaction skills, rapport, and achieving behavioral objectives. Feedback was also found to contribute significantly to a student's positive attitude to teaching.

SCIENCE TEACHERS' SELF ANALYSIS IN THE AREA OF 'DISCOVERY'

Frank X. Sutman
Temple University

Patricia Sparks
Stamford (Conn.) High School

A science methods course for inservice teachers was designed to give maximum experience with self discovery. The course was organized around ten activities that required the teachers to seek answers for themselves through the science laboratory, the library, and the instructional materials center; but minimized their role as a source for answering questions. As part of the "discovery" experience the teachers were asked to examine their own teaching for its "discovery" orientation. This was done by using a self-evaluation checklist developed by science specialists at the U.S. Office of Education. The teachers completed the checklist during the first meeting of the course and again at the end of the 15 week semester. The checklist items were categorized into three major areas: (1) objectives in teaching; (2) structure of the subject; and (3) approach to teaching. The third category was divided further into two sub areas: qualitative approach and quantitative approach.

The results of the teachers' responses to the checklist were analyzed to determine to what extent, if any, the teachers believed their teaching had become more oriented towards "discovery" during the semester. Using a weighted scale, the investigators found the following overall percentage changes towards more "discovery" in the categories listed above.

Category	Per Cent
Objectives	30
Structure	27
Approach - qualitative	25
Approach - quantitative	33

The data indicate generally that the teachers enrolled in the methods course purporting to have concern for "discovery" believed their own teaching to be oriented more towards "discovery" at the end of the methods course. No direct cause-and-effect relationship is claimed to exist between the methods course with its orientation and the self-evaluated increase in "discovery" orientation by the teachers in their own teaching. The study deliberately attempts to answer very few questions. Rather it raises many questions. For example, are the criteria included in the U.S. Office Checklist valid for determining the extent to which teaching is "discovery" oriented? Are inservice teachers able to assess changes in approach in their own teaching? Within the limitations of this preliminary study, why are the overall total weighted changes in responses towards greater "discovery" orientation so alike for the four categories selected for the classification system? Further rigorous research needs to be done in this area.

A COMPARISON OF THE EFFECTIVENESS OF AN INSERVICE PROGRAM AND A PRESERVICE PROGRAM IN DEVELOPING CERTAIN TEACHING COMPETENCES

Frank D. Breit
David P. Butts
The University of Texas

The formation of federally supported national curriculum projects has led to the development of a number of new curriculum innovations. Evidence that many teachers are inadequately prepared to teach the new curriculum has led to the development of teacher education programs especially designed to develop the necessary competences in teachers. The effectiveness of such a program in developing teacher competences is dependent upon the characteristics of the participants. Programs have been developed for use with preservice teachers as well as inservice teachers. The different characteristics of the two populations could affect the outcomes of a program given to both groups.

This study examined the relative effectiveness of a teacher education program given at the preservice level and at the inservice level in the development of certain teacher competences. The specific teacher competences studied were knowledge of science content, positive perception of goals and methods of a curriculum innovation, and facility in coping with a learning environment which emphasized the child's responsibility for his own learning. Also examined in the study was the relationship of certain factors to the successful development of teacher competences by program participants. The specific factors studied were initial level of competence, intensity of initial attitudes, teaching experience, amount of college science, and number of years since last science course.

Four groups of individuals were included in the study. The preservice version of the program under study was given to fifty-eight students enrolled in an undergraduate science methods course at The University of Texas. Fifteen students enrolled in an undergraduate social studies methods course at The University of Texas served as a control for the group above. The inservice version of the program under study was given to 28 elementary school teachers enrolled in an elementary school science workshop. Eleven elementary school teachers enrolled in the summer school at The University of Texas served as a control for the group above.

The *Science Process Measure for Teachers*, *Instructional Decisions Test*, and a semantic differential were used to measure the teacher competences under study. Scores on the above instruments were collected for all individuals in the study as pretest data and as posttest data.

The relative effectiveness of the teacher education program at the preservice level and at the inservice level in developing teacher competences was investigated using analysis of variance. The relationship between certain factors and successful development of teacher competences was analyzed using multiple linear regression.

The results of the study indicate that the program was successful in developing knowledge of the processes of science with both preservice participants and inservice participants. However, a greater increase was found for the inservice participants. The high correlation between pretest scores and change scores on the Science Process Measure for Teachers indicates that the greater change in knowledge in the inservice participants was related to their lower initial level of knowledge. This could indicate that the instruction given is more beneficial for those with a lower level of knowledge.

Both preservice participants and inservice participants made substantial change in their instructional decision behavior. The preservice participants began at a significantly higher level than the inservice participants and retained this difference at the end of the program. This seems to indicate that the aspects of the program which dealt with instructional decision behavior were of equal benefit to individuals at various levels of competence and with or without teaching experience.

The concepts for which attitude changes were found differed for preservice participants and inservice participants. Inservice participants showed a change in attitude towards the program inself along with methods of instruction utilized in the program. On the other hand, preservice participants did not show much change in attitude towards the program itself but did show a change in attitude toward the philosophy of the new curriculum under study in the program. The changes in attitude noted seem to indicate that the program itself had a bigger impact on the inservice participants. It is possible that this is related to how relevant the participants see the program. Inservice participants, having taught, can see a greater need for the type of help offered by a teacher education program. The lack of change in attitude by inservice participants towards teaching methods espoused by the program could be due to the difficulty of changing basic attitudes towards instructional methods of experienced teachers.

Concurrent Sessions L

Session L-1 How Children Learn in City and Suburb

Chairman: Morseley Giddings, Center for Urban Education and Brooklyn College of the City University of New York

1. "An Experimental Comparison of Urban Children with Suburban Children on Eight Tasks of Basic Skills," Kenneth D. George - University of Pennsylvania.
2. "The Effect of Two Instructional Programs (Science-A Process Approach and the Frostig Program for the Development of Visual Perception) on the Attainment of Reading Readiness, Visual Perceptual, and Science Process Skills in Kindergarten Children," William C. Ritz - Eastern Regional Institute for Education.
3. "An Analysis of the Effects of Selected Experiences on the Ability of Pre-School Children to Use Conservation of Length and Conservation of Length Relations," Russel L. Carey and Leslie P. Steffe - University of Georgia
4. "The Influence of Selected Science Experiences on the Attainment of Concrete Operations by First Grade Children," Donald Bernard Neuman - University of Wisconsin

AN EXPERIMENTAL COMPARISON OF URBAN CHILDREN WITH SUBURBAN CHILDREN ON EIGHT TASKS OF BASIC SKILLS

Kenneth D. George
University of Pennsylvania

Many reasons are given to explain why children from lower income urban homes do poorly in school. Perhaps one of the main reasons for this is due to the fact that these children lack some of the basic skills needed in order to work with the materials normally used in an elementary school, especially in an elementary school science program.

If this assumption is true, there should be a difference between children from lower income urban homes and children from higher income suburban homes on performances in some basic tasks. The null hypothesis of this study is that there was no difference between the population proportions for first, second, and third grade children on the following eight tasks:

1. Identification of six basic colors.
2. Drawing of four shapes.
3. Counting in order, starting with one.
4. Identification of common characteristics.
5. Indicating the positions for the hands of a clock at 3:00, 12:00, 2:30, and 4:40.
6. Distinguishing between right and left, with respect to themselves and then with respect to a person facing them.
7. Measuring a rectangular box with a ruler.
8. Identification of a "hot" reading and a "cold" reading on a thermometer.

During the 1967-68 school year, about 1500 children were studied. The children were randomly chosen from the schools that agreed to cooperate in the testing program. Once the local principal specified the number of children at each of the three grade levels, each student was assigned a number. The students whose numbers corresponded to those found in the Table of Random Numbers were selected.

There was a significant difference between children from low-income urban families and higher-income suburban families on many of the tasks selected for this study. The children from the urban sample did significantly better on the following tasks:

1. Drawing a triangle (second grade).
2. Responding to numerical counting beginning with one (second grade).
3. Distinguishing between right and left with respect to a person facing them (second and third grade).

The children from the suburban sample did significantly better than the children from the urban sample on the following tasks:

1. Distinguishing colors (first and second grades).
2. Drawing a circle, square, and rectangle (second and third grade); Drawing a triangle (third grade).
3. Responding to numerical counting beginning with one (first grade).
4. Placing the hands of a clock at 12:00, 2:30, and 4:40 (second and third grade); 3:00 (third grade).
5. Distinguishing between right and left with respect to themselves (third grade).
6. Measuring with a ruler (first, second, and third grade).

There were no significant differences between the children from both samples with respect to the following tasks:

1. Distinguishing colors (third grade).
2. Drawing a circle and a triangle (first grade).
3. Responding to numerical counting beginning with one (third grade).
4. Placing hands of clock at 3:00 (second grade).
5. Distinguishing between right and left with respect to themselves (second grade).
6. Using a thermometer (second and third grade).

In the true sense of the word, the urban children in this study were "disadvantaged" because they lacked some of the skills possessed by other children. Many teachers know that these children experience many failures in their learning activities and therefore usually do more poorly in school. There are more drop-outs from this group of children. It is estimated that by 1970, one-half of the children in large cities will be disadvantaged unless the currently developing programs of compensatory education are more successful. On many of the skills studied in this investigation, third grade urban children were comparable to first grade suburban children.

Teachers who work with disadvantaged children must begin to use instructional materials that will help them to acquire the basic skills that they lack. These skills must be emphasized in our teaching of young children. Perhaps the new curriculum programs in elementary school science will help disadvantaged children to acquire the skills needed to achieve success.

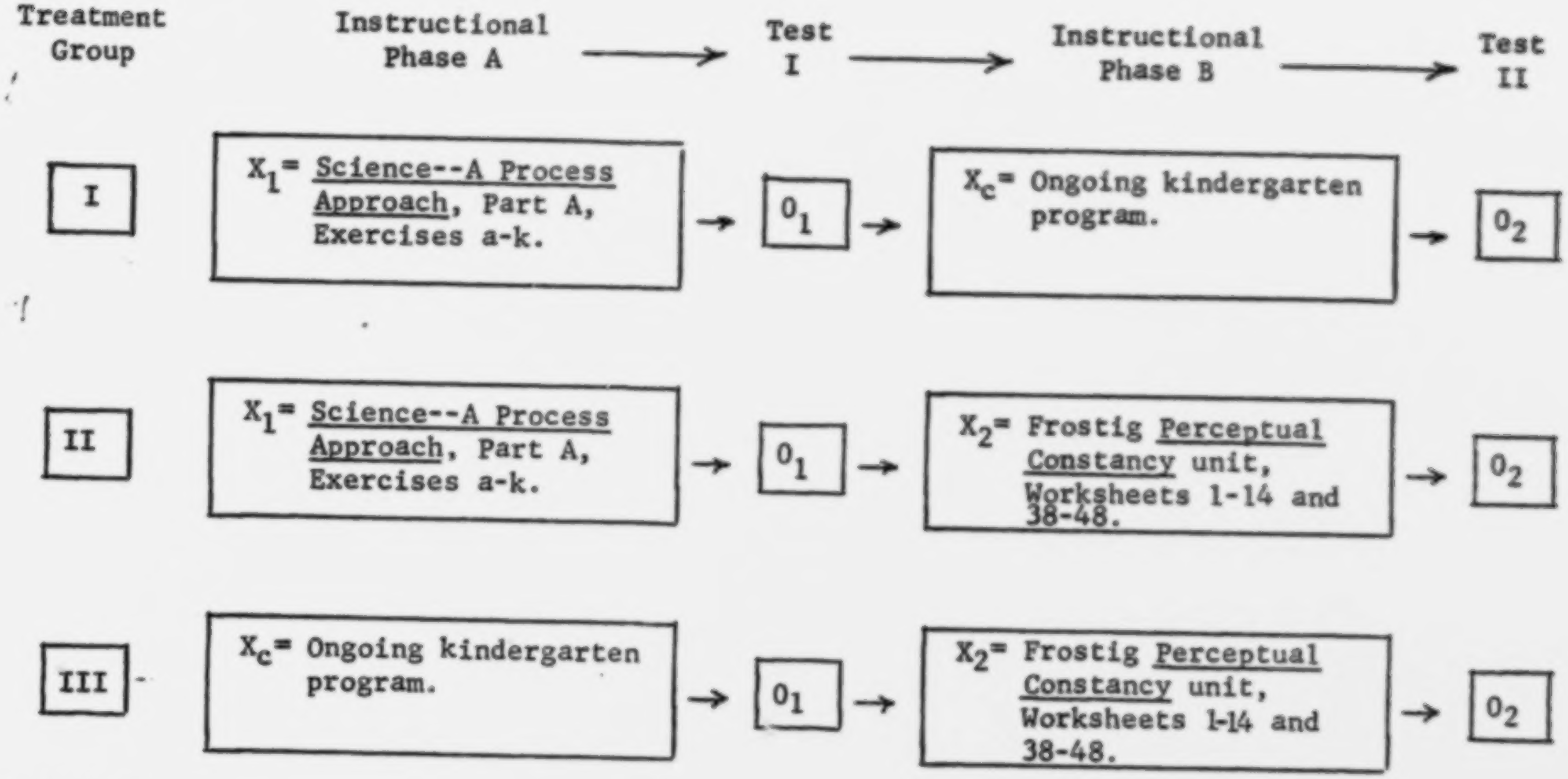
THE EFFECT OF TWO INSTRUCTIONAL PROGRAMS, SCIENCE-A PROCESS APPROACH AND THE FROSTIG PROGRAM FOR THE DEVELOPMENT OF VISUAL PERCEPTION, ON THE ATTAINMENT OF READING READINESS, VISUAL PERCEPTUAL, AND SCIENCE PROCESS SKILLS IN KINDERGARTEN CHILDREN

William C. Ritz
PCIP Program

The purpose of this study was to examine the effects of portions of two instructional programs, *Science-A Process Approach* and The *Frostig Program for the Development of Visual Perception*, and a combination of portions of these programs on the attainment of reading readiness, visual perceptual, and science process skills in kindergarten children. Reading readiness level was measured through the administration of *Metropolitan Readiness Tests, Form B*. Visual perceptual level, shown by two indicators (Perceptual Quotient, and "Constancy of Shape" scale scores), was assessed via The *Frostig Developmental Test of Visual Perception*. Behavioral performance in a substantial number of the science process skills which constitute the instructional goals of the first half of Part A of *Science-A Process Approach* was also measured. The research instrument used for this purpose was a group measure, *Competency Measures for Groups*, which parallels closely the individual competency measures of exercises a-k of *Science-A Process Approach*, Part A.

Twenty-four classes of kindergarten children from ten different school systems located in New York State and Pennsylvania served as subjects in this study. Figure 1 illustrates the experimental design which was employed. Group I consisted of eight classes who participated in the science experiences of exercises a-k of *Science-A Process Approach*, Part A, during a time interval designated "Instructional Phase A." These pupils did not receive visual perceptual training during the subsequent Instructional Phase B. The eight classes of Group II also received *Science-A Process Approach* instruction during the initial instructional phase. In addition, these children received visual perceptual training (The *Frostig Perceptual Constancy* unit) during Instructional Phase B. Group III consisted of eight classes who did not participate in *Science-A Process Approach* work during Instructional Phase A. The Group III classes did, however, receive the visual perceptual training of the *Frostig Perceptual Constancy* unit during the subsequent instructional phase.

Paradigm Illustrating Instructional Sequence and Experimental Design



Treatment Group	Instructional Phase A	Test I	Instructional Phase B	Test II
I	X_1= Science--A Process Approach, Part A, Exercises a-k.	0_1	X_c= Ongoing kindergarten program.	0_2
II	X_1= Science--A Process Approach, Part A, Exercises a-k.	0_1	X_2= Frostig Perceptual Constancy unit, Worksheets 1-14 and 38-48.	0_2
III	X_c= Ongoing kindergarten program.	0_1	X_2= Frostig Perceptual Constancy unit, Worksheets 1-14 and 38-48.	0_2

FIGURE I.

Ten pupils were randomly selected for testing from each of the 24 classes. The skill attainment of each of these pupils was measured via each of the three research instruments on two separate occasions. The first of these occurred at the end of Instructional Phase A, whereas the second coincided with the conclusion of Instructional Phase B. Absentee problems reduced the final sample to eight pupils per class, or a grand total of 192 pupils.

A total of 20 hypotheses were stated in this study. Eight of them involved comparisons of mean test scores among the three treatment groups. The remaining 12 hypotheses focused on relationships existing among subject achievement on the research instruments and between the scores of each measure and subject age expressed in months.

The only significant differences found at the end of Instructional Phase A were differences in science process scores existing between the groups of children receiving Science-A Process Approach instruction and the group not receiving this instruction. Those differences noted at the end of Instructional Phase B involved group differences with respect to visual perceptual skills. Significant differences in Perceptual Quotient and "Constancy of Shape" scale scores were found to exist between those groups receiving visual perceptual training and the group not receiving this training. It was noted that the pupils of the group that received Science-A Process Approach instruction followed by visual perceptual training attained significantly higher Perceptual Quotient scores than did the pupils of the other two groups. No significant differences in readiness scores were found to exist among the groups at the end of either instructional phase.

The scores of all three research instruments were found to correlate significantly with each other in each case. It was noted that a significant negative correlation existed between Perceptual Quotient and subject age in Groups I and III at the end of each of the instructional phases, but this was not true in the case of Group II. The relationships of the other test scores with subject age was less clear. Metropolitan Readiness Tests scores were found to correlate significantly with age in Group I at the end of Instructional Phase A and also in Group II classes at the end of each of the two instructional phases. Competency Measures for Groups scores correlated significantly with subject age in only one case, that of Group II at the end of Instructional Phase B.

The most significant finding of this study appears to be its demonstration that science and/or visual perceptual instruction can be included in kindergarten programs without impairing the reading readiness attainment of children trained in this manner. The inclusion of these instructional programs not only failed to bring about a reduction of the reading readiness of these children, but appears to have enhanced their visual perceptual and/or science process skill attainment. This finding seems to refute the opinion that since readiness attainment might suffer as a result there should be no time for science and/or visual perceptual instruction in kindergarten. The evidence of this study stands in direct contradiction to that viewpoint. Instead, it supports the contention that teachers can devote reasonable amounts of time to programs such as Science-A Process Approach and The Frostig Program for the Development of Visual Perception without fear that the reading readiness of their pupils will suffer as a result.

AN ANALYSIS OF THE EFFECTS OF SELECTED EXPERIENCES ON THE ABILITY OF PRE-SCHOOL CHILDREN TO USE CONSERVATION OF LENGTH AND CONSERVATION OF LENGTH RELATIONS

Russell L. Carey
Leslie P. Steffe
University of Georgia

The purpose of this study is to analyze the effects of selected experiences in length comparison, conservation of length, and conservation of length relations on the ability of four- and five-year-old children to use conservation of length and conservation of length relations. The following questions are of basic concern in the study.

1. (a) If children are able to establish a length relation between two curves, are they able to conserve that relation without formal experiences? (b) If children are able to establish a length relation between two curves, are they able to conserve the relation involving properties or logical consequences of that relation without formal experiences?

2. (a) What is the effect of selected experiences on the ability of children to conserve length relations? (b) What is the effect of selected experiences on the ability of children to conserve length relations involving properties or logical consequences of length relations?

3. Are children able to conserve length without formal experiences?

4. What is the effect of selected experiences on the ability of children to conserve length?

5. What is the relationship between certain student characteristics and scores earned on Conservation Tests?

The subjects were 18 four-year-old children and 33 five-year-old children. All children received instructions in establishing length relations between two curves, conserving length relations, and conserving length. Small group instructional procedures were utilized. Identical pre and post Conservation Tests were administered. The pupils were treated on a one-to-one basis for evaluation.

The conclusions are summarized as follows:

1. A small percentage of the children conserved length relations after formal experiences in length comparisons. After formal experiences in conservation more than one-half of the children were able to conserve length relations.

2. Few of the children were able to conserve length relations involving properties or logical consequences of length relations with instruction only in length comparison. After formal experiences in conservation of length relations, a statistically significant number of five year old children were able to conserve length relations and properties or logical consequences of length relations. Formal experiences in conservation did not statistically change the four year olds.

3. Few of the children are able to conserve length involving both the reflexive and non-reflexive property with only formal experiences in establishing a length relation. After selected experiences in conservation, a statistically significant number of children were able to conserve length.

4. There appears to be little, if any, relationship between the variables Age, Verbal Maturity, I.Q., and Social Class and the ability of four and five year old children to conserve length and length relations.

THE INFLUENCE OF SELECTED SCIENCE EXPERIENCES ON THE ATTAINMENT OF CONCRETE OPERATIONS BY FIRST GRADE CHILDREN

Donald Bernard Neuman

The main objective of this study was to investigate the influences of certain science experiences on the attainment of concrete operations by first grade children as revealed by selected Piagetian conservation tasks. These tasks involved the conservation of liquid quantity, conservation of discontinuous solid quantity, and conservation of weight.

The study was carried out in Okemos, Michigan, and involved all 87 children in the three first grade classes and one first-second grade transition class in the Cornell School. At the outset of the study, each child was randomly assigned to one of four classes for the purpose of studying science. Two classes, designated as the experimental group by the investigator, studied science by means of the methods and materials developed by the Science Curriculum Improvement Study (SCIS). The other two classes, designated as the control group, studied science by means of the school's usual program.

For the purpose of determining differences in developmental growth between the experimental and control groups, all children were shown sixteen-millimeter color motion pictures of the four conservation tasks. Tape-recorded sound tracks consisting of information pertaining to the films and instructions for answering a question about each film were also presented to the children. The children were given a pre-test consisting of the four films. After an eighteen-week treatment period, all of the children were given a post-test consisting of the same four conservation films.

The data to which statistical tests were applied were obtained from the results of the conservation tests. Parametric and non-parametric models were used to analyze these data. On the basis of the analyses, the following conclusions were indicated:

(1) There were no differences in the attainment of concrete operations between children who studied science by means of the SCIS program and children who studied science by means of the usual program. (2) There were no differences in the attainment of concrete operations between boys and girls. (3) The girls who studied science by means of the SCIS program scored significantly higher on the post-test than on the pre-test. (4) No conclusive evidence was produced to indicate a dominance of the experience factor in promoting attainment of concrete operations. (5) Children appeared able to conserve weight at the same age that they conserved quantity.

Session L-2 On the Teaching of Earth Science

Chairman: John Montean, University of Rochester

1. "The Effect of Natural Small-Scale Geologic Features on the Concepts of Fluvial Geology Among Fifth and Sixth Grade Children," Michael Robert Cohen - Indianapolis Downtown Campus of Indiana University.
2. "A Model of Earth Science Field Experiences for Urban Elementary Students," Warren E. Yasso and Daniel J. Brovey - Teachers College, Columbia University.
3. "Changes Occurring in Course Requirements in Earth Science Teacher Preparation Programs in the Period from 1964 to 1968," Victor J. Mayer - The Ohio State University.
4. "An Exploration of Potentialities, Advantages, and Problems of Multi-Investigator, Parallel Researches in Science Education," Hulda Grobman - New York University.

THE EFFECT OF NATURAL SMALL-SCALE GEOLOGIC FEATURES ON THE CONCEPTS OF FLUVIAL GEOLOGY AMONG FIFTH AND SIXTH GRADE CHILDREN

Michael Robert Cohen
Indiana University

Geologists and educators have suggested the use of small-scale geologic features for learning geologic concepts. These features provide valid analogies to macro-geologic features and are common on school grounds and backyards. Since field work is an important part of the learning of geology and is usually neglected because of economic and legal problems as well as a scarcity of appropriate nearby locations, small-scale features appeared ideal for increasing the kind and extent of geologic field study.

This study measured the effect of activities using small-scale geologic features on the concepts of erosion, deposition, and lakes held by fifth and sixth grade children. Forty-eight children were selected from all the fifth and sixth grade classes in a central school in central New York State, so that there were equal numbers of each sex, grade, and highest and lowest I.Q. levels. Half of the sample were measured before the field activities, and the entire sample, except for those children abse from the activities, were measured after the field activities.

The measurement consisted of a thirty-to-forty-minute individual interview. The interview was based on the premises Piaget suggested in The Child's Conception of the World. The first few questions were openended and allowed the child to express his own spontaneous ideas. Subsequent questions probed at the concepts touched in the earlier questions from different points of view.

Seven of the classes participated in the field activities which used the small-scale features. The activities were selected from those suggested by others and those judged successful in pilot studies. The children were taught by their fifth and sixth grade science teacher. The field activities were suited to her style of instruction. The children would engage in an activity and then compare results and ideas in class discussions led by the teacher, but oriented to the child.

Before the field experiences the fifth and sixth grade children had similar concepts with respect to general ideas. They were all familiar with erosion which they said was caused by water. Most children felt that lakes grow larger because of the rain falling into them. As the questions became more specific, the grades showed differences. The sixth grader had more sophisticated ideas, although in many cases the primitive concepts common to the fifth grader were still evident in their answers.

After the field experiences the interviews indicated that the activity on lakes had no effect on either grade. The activities on erosion and deposition had a small effect on the sixth grade and a large effect on the fifth grade. The sixth graders had a clearer understanding of the processes of erosion and deposition. The fifth graders were raised beyond the sixth graders' pre-activity level of understanding of the processes of erosion and deposition.

The results indicate that the use of small-scale geologic features in the teaching of geology may not be universally successful. The teacher involved in this study and those who took part in the pilot work were very impressed with the activities. The children seemed to have an enjoyable and interesting time. However, these feelings were deceptive. The measurements show that in some cases the children learned much less than was thought possible by the teacher. The sixth grade children had been exposed to other geologic ideas such as mountain building and glaciers, and possibly considered the field activities below their needs. On the other hand, the fifth graders were perfectly suited to the activities on erosion and deposition, and gained a great deal from the experience. The results suggest that fifth graders can gain more from activities on lakes if these activities are related and combined with these activities on erosion and deposition in which the students participated.

A MODEL OF EARTH-SCIENCE FIELD EXPERIENCES FOR URBAN ELEMENTARY STUDENTS

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There is a need to foster meaningful Earth-Science concept formation among urban and ghetto upper-elementary students. Concepts that demonstrate the universality of geologic forces and changes are part of the common experiences of both those in the city and in the suburbs. Field trips to the uncluttered suburban environment are a possible means of illustrating such concepts, but could not such illustrations also be provided in an urban environment? Considerations of travel time and distance, among others, dictate the maximum possible use of the local environment. However, a general lack of geologic field experience among upper-elementary teachers has prevented even minimal use of the Earth-Science resource of urbia.

Toward a solution of these problems, a model has been developed that establishes criteria for recognition and use of urban geologic sites. The site concept employed in the model is different from the field-trip concept of Earth-Science learning, partially because each geologic site is considered as a single entity divorced from regional, geologic history and structure, because site experiences emphasize those Earth-Science concepts usually ignored in conventional field trips, and because each site is close to a neighborhood school. Support and encouragement for investigation of the geologic site model was provided by the Center for Urban Education of New York City.

A geologic site is considered appropriate when it meets the primary criteria of (a) location within walking distance of local elementary school, (b) safety from natural or man-made hazards, (c) simple illustration of one or more useful Earth-Science concepts, and (d) potential for reviatation by teachers and students to observe natural change. Of slightly lesser importance in site selection are the secondary criteria of (a) sufficiently large site area to allow simultaneous involvement of students in the same learning task, (b) sufficiently large volume of earth materials, so that samples can be removed by many student groups for further analysis, (c) presence of a variety of soil, sediment, rock, or structural interrelationships, and (d) closeness to public water fountains, lavatories, etc.

In the present pilot study the investigators, acting as professional earth scientists, selected six sites in the upper part of the Borough of Manhattan, New York City, that met the primary and secondary criteria. Each of the sites exhibited all or almost all of the following geologic features or phenomena: bedrock, fault, fold, dike, vein, differential weathering, glacial boulder or erratic, transported soil, stream drainage pattern, soil erosion, sediment, and mass wasting. The task of the investigators was to sequence the Earth-Science experiences at each site and to document the suggested sequencing by text and photographs which would allow self-guided visits by untrained teachers and students. A document that reports on the pilot study is in final stages of preparation for publication.

It is intended that this study will be expanded to include geologic site experiences at rivers, beaches, etc. It is also hoped that this effort will engender similar attempts at site utilization by elementary teachers working alone or with the assistance of local, professional earth scientists.

CHANGES OCCURRING IN COURSE REQUIREMENTS IN EARTH SCIENCE TEACHER PREPARATION PROGRAMS IN THE PERIOD FROM 1964 TO 1968

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A survey conducted in 1964 found 123 colleges and universities with programs designed for the preparation of secondary school earth science teachers. Information collected from these institutions indicated the following: the most frequently required earth science courses were from the discipline of geology; courses in geography, meteorology, and astronomy were often required; the median number of semester hours of required earth science course work was 26; mathematics through calculus was required in less than one-third of the programs; except for mathematics, the requirements followed closely those recommended by various national committees on science teacher preparation.

Another survey, conducted in 1968, revealed that over 150 institutions now offer programs especially designed for the preparation of earth science teachers. In this paper, the results of the two surveys are compared, revealing certain changes in course requirements. Possible factors influencing these changes are the rapid acceptance of earth science as a secondary school subject with the consequent demand for earth science teacher preparation programs, the development and publication of the Earth Science Curriculum Project materials, and the acceptance of recommendations on program content made by the Council on Education in the Geological Sciences and the Earth Science Curriculum Project.

AN EXPLORATION OF POTENTIALITIES, ADVANTAGES, AND PROBLEMS OF MULTI-INVESTIGATOR, PARALLEL RESEARCHES IN SCIENCE EDUCATION

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Increasingly, meaningful research in science education is becoming a large-scale expensive venture that is beyond the means of the individual investigator without large-scale outside financing. However, not only are there some serious disadvantages to large-scale research projects, but the competition for available funding for such projects is increasing. Thus, it is timely to consider alternative strategies of small-scale research which permit realizing many of the advantages of larger-scale investigations. One such approach is the cooperative or multi-investigator research effort, wherein several investigators carry on independent but to some extent parallel investigations.

The proposed paper will summarize the methods of operation of the recent First Grade Reading Studies, which used this technique with considerable success and the allocation of roles and responsibilities between the 27 individual investigators in this study and the Study's Coordinating Center. This paper will consider how this approach differs from other multi-investigator related research; the advantages ensuing from this method of operation and its apparent limitations; and the possibilities of a similar approach in research in science education. The paper will conclude with a design for a hypothetical multi-investigator research project in science education, indicating the decisions to be made, the processes to be standardized, and the difficulties inherent in the implementation.

In brief, the 27 investigators in the First Grade Reading Studies carried out independent research studies, but in so doing, agreed on the grade level and subject area to be investigated, the timing and exposure period for the sample treatment, some expected learning outcomes, the minimum sample size for each investigation, the pre- and post-tests, and some data collection content and methods. Each investigator remained free to select his own experimental sample, to select curriculum materials for his individual study, and to administer additional measurement instruments. In this way, it was possible to explore effects of various approaches to the teaching of reading, keeping some agreed-upon variables and measurement instruments constant across 27 experimental populations. Each investigator worked with a sample small enough to permit some independent in-depth investigations, at the same time that there were 26 comparison groups for some other aspects of his treatment.

There are a large number of research problems in science education where past studies have been contradictory or inconclusive, perhaps because of noncomparability of data and/or treatment. Many of these would lend themselves to the multi-investigator, parallel research approach. For example, more definite information is needed on the interaction of class size, curriculum, teaching method, and use of the laboratory in science teaching. Needed also is more information on the effects of various curricula holding constant such variables as length of treatment and relative emphasis on laboratory, demonstration, discussion or lecture.